MODERN GEOGRAPHY

BOOK I

FOUNDATIONS OF GEOGRAPHY

BY

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ILLUSTRATIONS

road, brook, and woodland is shown, so that in many ways they foreshadow the later work of the Ordnance Survey. At the end of the eighteenth century the value of accurate and detailed maps was beginning to be fully realised, and the publication of numbers of county maps followed. This was largely due to the generosity of the Royal Society, which offered large prizes for the best maps on the scale of 1 inch to 1 mile.

The Growth of the Ordnance Survey Department

The dictionary definition of the word "Ordnance" is "cannon, artillery, etc.", and one may be inclined to ask why a term of military meaning should be applied to the apparently non-military occupation of surveying. The answer lies in the fact that maps are of inestimable value in military campaigns. In Britain this was fully realised during the 1745 Rebellion, when the idea originated of making reliable maps of the Scottish Highlands. These maps were made for the Army under the direction of Major-General Roy, who after the completion of his work in Scotland, was, in 1765, appointed "Surveyor General of Coasts, and Engineer for making Military surveys in Great Britain". Roy died in 1790, having done valuable work in both actual surveying and in investigating remains of historical interest, especially those of Roman origin. Before his death he repeatedly advocated the detailed survey of the whole of Britain, and in 1791 the Government officially established the Trigonometrical Survey of Britain. Thus began the "Great Triangulation" which was not completed until 1853.

Triangulation is a system of measurement based on the fact that if one side and two angles of a triangle are accurately known, then the exact lengths of the other two sides can be calculated. Let A, B, and C (Fig. 1) be three prominent landmarks. Then if the side AB (the base line) is accurately measured, and also the angles BAC and ABC, it is possible to calculate the exact lengths of BC and AC. If D is another landmark, then after measuring the angles DCB and CBD and using the *calculated* length of BC the exact lengths of CD and BD can be obtained. So the surveyor proceeds from triangle to triangle, and it is never again necessary to measure any linear distances.

For the first triangulation of Great Britain two base lines were measured, one on Salisbury Plain and one near Lough Foyle in Ireland. Later a side of a triangle was *measured* in Scotland as a test, and so accurate was the process of triangulation that the error was only one inch per mile. The instrument generally used to measure the angles is known as a theodolite. The sides of the triangles of the primary triangulation were of the order of about 30 miles long. Sometimes the sides of these main triangles were divided and smaller triangles observed, and these again were further subdivided if desired. All the major features of the land were thus fixed in accurate relation to one another. Further details were then filled in by various other methods of surveying, viz.

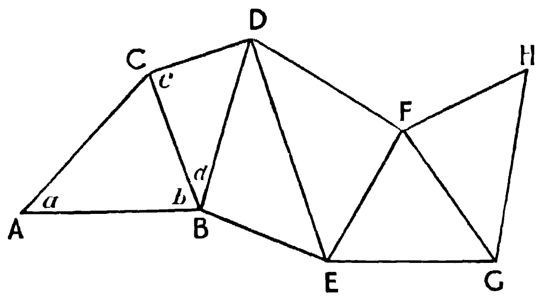


Fig. 1. Principle of Triangulation.

by the use of measuring chains, the plane table, the prismatic compass, etc. The first official Ordnance Survey map to be published was that of Kent (1801). The scale was 1 inch to 1 mile, and on it were marked towns, villages, streams, roads, wood, and parks. Relief was shown by hachuring (see page 9).

The year 1824 marked the next step in the progress of the Ordnance Survey. It was then that a survey of Ireland on the scale of 6 inches to 1 mile was authorised. In 1840 a similar survey of Great Britain was commenced. Finally in 1863 it was decided to survey the whole of Great Britain, except for mountainous and barren areas, on the scale of 25 inches to 1 mile. When this was completed the work of revising the earlier maps began, *i.e.* the insertion of new roads, railways, houses, etc. Each one-inch map is supposed to be

revised every fifteen years, but the two World Wars have retarded this work. The first of the O.S. maps were printed entirely in black; to-day most of them are printed in well chosen colours, and are, therefore, much more easily read.

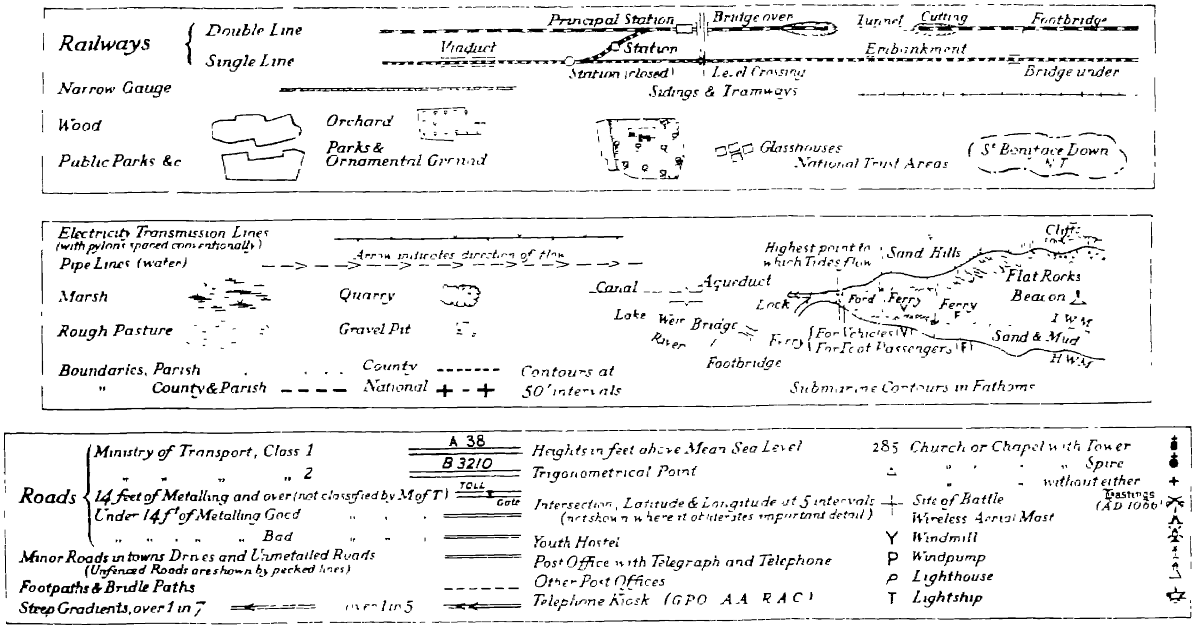
The Ordnance Survey Department has also published Geological Survey maps on a scale of 1 inch to 1 mile for the whole of Great Britain, and similar maps on a "six-inch" scale are in process of publication. Land Utilisation maps have also been published. These show woodland in dark green, meadow-land in light green, arable land in brown, heath, moorland, etc., in yellow, garden and orchards in purple, and land of no agricultural value in red

Types of Maps

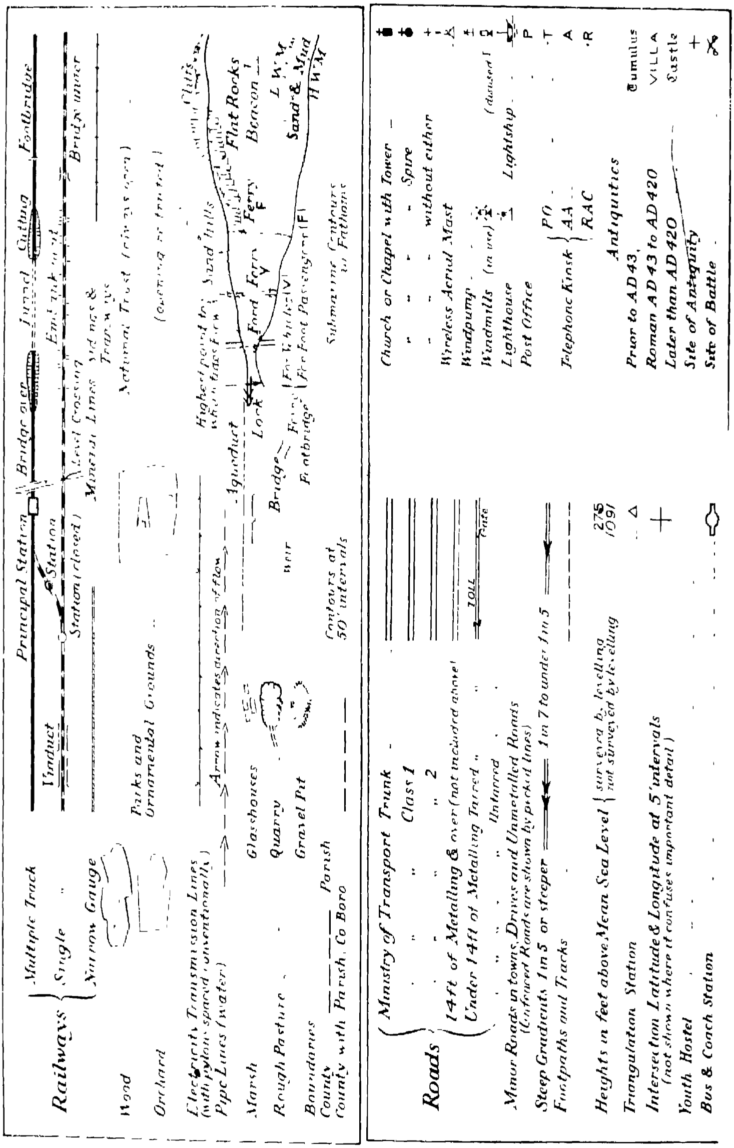
(*a*) ONE-INCH MAPS.– The best known of the "one-inch" maps to-day is probably the "Popular Edition". On this map contour lines are drawn in brown at intervals of 50 ft. Rivers and lakes are marked in blue, woods in green, roads in red, brown, yellow, or white, according to classification, and railways in black. The new Seventh Series of this map is now being issued, but it will probably be several years before the whole country has been covered.

In the Seventh Series a clearer style of lettering has been used, and grey instead of black for built-up areas. All lettering referring to water is now in blue and there are a number of changes in conventional signs. (A key plate showing those of the Sixth Series will be found opposite, and those of the Seventh Series facing page 5.) Note in the latter the revised road classification, new signs for railways, and changes in connection with National Trust Areas, Youth Hostels, and Telephone Kiosks. Bus and coach stations are now indicated.

In both the Sixth and Seventh Series, reference to the map is facilitated by the use of the National Grid. This consists of a series of numbered lines drawn across the map in an east-west direction 1 kilometre apart and another series drawn in an approximately north-south direction. Owing to the convergence of meridians towards the Pole, the latter series of lines, being always at right angles to the east-west lines, can only be exactly north and south at one point on the complete map of the British Isles, but the variation from true north and



SYMBOLS USED IN THE NEW POPULAR (SIXTH) EDITION OF THE ONE-INCH ORDNANCE SURVEY MAPS



SYMBOLS USED IN THE SEVENTH SERIES ONE-INCH ORDNANCE SURVEY MAPS.

south is never very large and on the inset map in this book is less than 1°. Every tenth line in each series is shown on the map by a heavier (full) line.

The object of this grid is to facilitate reference. To refer to a particular kilometre square, find on the edge of the map the two figures corresponding to the *west* boundary of the square and write them down followed by the two numbers corresponding to the *south* margin of the square. Thus the square containing the village of Houghton, on the inset map at the back of the book, is 0111. By eye estimation of tenths of the side of a kilometre square we can refer to a point to within 100 metres. For example, the cross-roads at Houghton has the six-figure reference 019116.

A difficulty arises when we are using maps covering a large area because our reference numbers repeat at intervals of 100 kilometres. To overcome this difficulty each 100 kilometre square has been given two reference letters, which can, if necessary, be prefixed to the figure reference. Thus for the cross-roads at Houghton we could write TQ019116. (When the National Grid was first introduced numbers were used instead of letters and the above reference was then 51/019116.) No other point in the whole of the British Isles has this reference. Since the map at the end of this book is of an area less than 100 kilometres in either direction there will be no need to use the prefix letters and in practice references will be to the kilometre square, *i.e.* will be four figures only.

(*b*) TWO-AND-A-HALF-INCH MAPS.—This series of maps, *approximately* 2½ inches to the mile, is based on the six-inch map. The current style uses grey for certain features, *e.g.* non-public buildings, woods, orchards, etc. Contours are at 25 ft intervals, and many of the conventional signs are similar to those used in other O.S. maps.

(*c*) SIX-INCH MAPS.—These maps are printed in black, with contours in red at vertical intervals of 50 ft. Boundaries of towns, urban districts, rural districts, etc., are shown by various types of broken lines. Every field is shown, and all bench marks (*i.e.* points whose height above sea-level has been accurately determined) are inserted.

(*d*) TWENTY-FIVE-INCH MAPS.—This type of map is really a plan. The fields are not only shown, but they are numbered, and their areas denoted to a thousandth part of an acre. In a town it is possible to pick out every street, house, garden, school, and public building. In this map the roads are of their true width (this is not possible in the maps of smaller scale, *e.g.* the one-inch maps). Such maps are extremely useful to town councils and other local government bodies.

(*e*) FIFTY-INCH MAPS.—An enlargement of (*d*) above.

Conventional Signs

These are shown opposite pages 4 and 5. In addition, antiquities are shown on the map in special type. Roman remains are marked with square Roman lettering, *e.g.* STANE STREET (9410) and CAMP (0217). Other features of historical and antiquarian interest are indicated by Old English lettering, *e.g.* Tumuli (8916), Celtic Fields (0412).

EXERCISES

1. Give the meanings of the letter P at Watersfield (0115), and the letters N.T. in 9418.

2. If you lived at Bignor (9814) where would you go to send a telegram?

3. If you lived in South Stoke (0209) where would you go to send a telegram?

4. What do the following indicate: (*a*) the figure 408 on a main road (0009); (*b*) the figure 450 in 0011; (*c*) the characters A.29 (0012); (*d*) the characters B.2139 (0011)?

5. What does the following indicate: figure 123 on the main road (8509)?

6. How would you go from North Stoke (0110) to Houghton (0111)?

7. What route would you follow if you were (*a*) motoring; (*b*) walking from Amberley (0213) to Bury (0113)? Why do the routes you choose differ?

8. Find examples of coniferous woods, deciduous woods, parks, inns, lakes, canals.

9. Find as many examples as possible of (*a*) Roman remains; (*b*) other historical remains.

10. How does the railway linking Midhurst (8821) with Chichester (8604) differ in type from that linking Pulborough (0418) with Arundel (0107)?

11. Which railway station is most easily accessible from South Stoke (0209), (*a*) by car; (*b*) on foot?

12. What is the direction (*a*) from Arundel (0107) to Houghton (0111); (*b*) from Rackham (0413) to Upwaltham (9413); (*c*) from Petworth (9721) to Singleton (8713); (*d*) from Summersdale (8606) to Fittleworth (0019)?

Scales

The scales of maps are linear scales. A scale denotes the relationship between the length of a *line* on a map and the length of that *line* on the ground.

Suppose a map or plan of a room 36 ft by 12 ft is required. It could be drawn 36 in. by 12 in. and give a true representation of the shape of the room. On such a plan 1 inch is used to represent 1 foot, so the scale is 1 inch to 1 foot. The sides of the room are each $\frac{1}{12}$ of their actual size. This scale can be denoted as 1 : 12 or $\frac{1}{12}$. This fraction is known as the *Representative Fraction* of the map (R.F.).

On "one-inch" maps 1 inch represents 1 mile. Since a mile contains 63,360 inches, and 1 inch represents 1 mile, every line on the map is $\frac{1}{63360}$ of its actual size on the ground. In atlases the Representative Fraction of each map is usually given in addition to an ordinary "line" scale. Suppose a Representative Fraction of an atlas map is 1 : 2,000,000, then 1 inch represents 2,000,000 inches. But 2,000,000 inches are the equivalent of nearly 32 miles, so that the scale 1 : 2,000,000 can be approximately expressed as "1 inch to 32 miles". Why should two kinds of scales be used? The reason is that fractional scales can be understood in any country. For example, a French boy would not readily grasp the meaning of "1 inch to 1 mile", in relation to French linear measurements. He would therefore look at the Representative Fraction, $\frac{1}{63360}$, and interpret it as 1 centimetre to 63,360 centimetres, *i.e.* 1 centimetre to 0·63 kilometres. Thus he would quickly grasp the scale of the English map.

Examine the linear scale on the given map. It is divided into six equal divisions of 1 inch each representing 1 mile.

Note carefully that the figure 0 is not placed at the extreme left-hand end, but at the right-hand end of the first division. To the left of the figure 0 the first division is divided into eight divisions of 1 furlong each, while to the right are five undivided spaces each representing 1 mile. This convention of placing the 0 at the end of the first division is to facilitate the measuring of distances on the map. For example, suppose the distance between Mid Lavant railway station (8508) and Singleton station (8613) has been measured with dividers. Then if the right-hand point of the dividers were placed on the figure denoting 2 miles on the scale, the left-hand point would be on figure 7 in the first division. The distance between the two stations is therefore 2 miles 7 furlongs.

If scales give the relationship between *lines* on the map and *lines* on the ground, what will be the relationship between *areas* on the map and *areas* on the ground?

Suppose the top of your school desk is 30 in. by 20 in. Draw a plan of the desk top on a scale of 1 : 10. Your plan will be 3 in. by 2 in. Cut out this piece of paper and find how many such pieces would be required to cover the whole desk top. The required number is 100. The area of the plan is $\frac{1}{100}$ or $\frac{1}{10^2}$ of the area of the desk top. Therefore if the linear scale is $\frac{1}{10}$ the area scale is $\frac{1}{10^2}$. On a "one-inch" map 1 sq. in. represents 1 sq. ml. But there are $(63{,}360)^2$ sq. in. in 1 sq. ml. Therefore the relation between the *area* of the map and the *area* of the ground is $\frac{1}{(63360)^2}$.

EXERCISES

1. What is the distance between Arundel station (0206) and Pulborough station (0418) as the crow flies?

2. What is the distance by road between Midhurst (8821) and Chichester (8604)? (Use a piece of fine string or cotton to make the measurement on the map.)

3. What area of land is represented by each of the squares on the map?

4. What is the total area of land surface represented by the whole map?

5. What fraction of its real size is Swanbourne Lake (0108)?

6. Which is the shorter route (railway or road) between Arundel (0107) and Chichester (8604)?

7. What is the R.F. of a map whose linear scale is (*a*) 1 in. to 2 ml.; (*b*) 25 in. to 1 ml.; (*c*) 6 in. to 1 ml.; (*d*) 1 in. to 10 ml.; (*e*) 1 cm. to 1 km.?

8. Express the following scales by an alternative method: (*a*) $\frac{1}{2500}$; (*b*) 1 : 1,000,000; (*c*) 1 : 31,680.

The Representation of Relief

The principal methods of showing relief on a map are by (*a*) hachuring; (*b*) hill-shading; (*c*) contours; (*d*) form lines; (*e*) contouring, with layering of colours. Sometimes two of

(a) (b) (c)

Fig. 2. The Representation of Relief.—(*a*) Hachuring (with contours), (*b*) Hill-Shading (with contours), (*c*) Contours.

these methods are combined, *e.g.* contours and hachures as in the new Relief edition of the "one-inch" maps.

(*a*) Hachures [Fig. 2 (*a*)].—Hachures are short lines representing the way in which water would flow from high to low ground. On steep slopes they are closer together than on the gentle slopes, but on flat ground there are none at all. The disadvantage of the use of hachuring alone is that it gives no indication of the actual height, and that both high plateaux and low plains are unshaded. The close hachuring of mountainous areas tends to obscure the other details of a map. Hachuring, however, gives the map a modelled appearance, and the relief features stand out clearly.

(*b*) Hill-Shading [Fig. 2 (*b*)].—Hill-shading shows the relief by "light and shade". Two methods are generally

adopted. (i) A light is imagined to be vertically over the area mapped. The steep slopes are then shown by dark shading, and the level land, whether of high or low altitude, is unshaded. (ii) A light is imagined to be shining from the north-west so that south- and east-facing slopes are more darkly shaded than those facing north and west. Both methods give a good general idea of the relief of the country, but the disadvantages are similar to those of hachuring, viz. that hill-shading does not give any idea of actual height, and that it is sometimes difficult to know whether a piece of land is sloping uphill or downhill.

(*c*) CONTOURS [Fig. 2 (*c*)].—*A contour line is a line joining all places which are the same height above sea-level.* The coastline is a simple example of a contour line since it joins all places 0 ft above sea-level. Since a water surface is level it follows that the edge of a pond or lake is also a contour line. Contouring is the most widely used method of showing relief. Most O.S. maps have contours drawn at vertical intervals of 50 ft, and in addition numbers of spot heights are marked. The position of the height of the contours and spot heights have been fixed by careful surveying with levels and other instruments.

(*d*) FORM LINES.—In many of the maps of British Colonies, where the surveys are as yet incomplete, form lines are used instead of contours. They are similar to contour lines but have not been accurately surveyed, and do not show definite heights. As a rule they are printed in broken lines, and so are easily distinguishable from contour lines.

(*e*) CONTOURING WITH LAYERING.—In this method layers or tints of colour are used to denote all the land between two given contours. For instance, dark green may be used for all the land between sea-level and 200 ft, light green for land between 200 ft and 400 ft, etc. These maps are extremely clear and attractive, and the relief of the land is easily apparent. In regions of great elevation it is, however, difficult to produce a layered map in which different colours are used for each contour interval. This is the method used in the "Tourist" maps of special areas.

The Reading of Contours

Two terms are often used in relation to contours, viz. Vertical Interval (V.I.) and Horizontal Equivalent (H.E.). Examine Fig 3. Suppose the line AB represents the surface of a piece of sloping ground. The dotted lines represent levels of 100 ft, 200 ft, and 300 ft above sea - level. The Vertical Interval is the vertical distance between two contours (DE, FG). This is usually uniform, but on some maps the V.I. is 100 ft up to 1,000 ft, and above 1,000 ft the V.I. is 250 ft. The Horizontal Equivalent is the horizontal distance between two contour lines, *i.e.* CD and EF. It varies according to the slope of the land, and is smaller where the slope is steep (EC) and larger where the slope is more gentle (GE). On a map the distance between the points C and E would be denoted by the shorter distance CD. All sloping surfaces are, as it were, projected on to a level plane before being mapped.

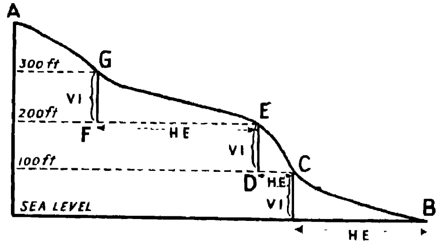


FIG. 3. VERTICAL INTERVAL AND HORIZONTAL EQUIVALENT.

EXERCISES

1. The scale of a map is 1 : 10,560. On it a cliff railway is shown by a line 1·2 in. long. The lower station is 125 ft and the upper 565 ft above sea-level. If the slope is constant, what is the actual length of the railway?

2. A hill path of even slope is 520 ft long. If the foot of the path is 300 ft above sea-level and the path is shown by a line 1 in. long on a scale of 1 : 5,760, what will be the height of the top of the path above sea-level?

Sections

One of the easiest ways of acquiring facility in reading contours is by drawing *sections*. The method is as follows:—

Suppose it is required to draw a section from A to B (Fig 4). Draw a line A′B′ equal in length to AB. At each end erect a vertical line (A′C and B′D). Examination of the map shows that the greatest height crossed by AB is between 600 and 700 ft. Mark off along A′C and B′D seven divisions of $\frac{1}{10}$ in. each; through these points draw seven fine lines parallel to A′B′, and number them in hundreds of feet (or according to the contour interval of the given map). Place the straight edge of a piece of paper along the line AB and on it map

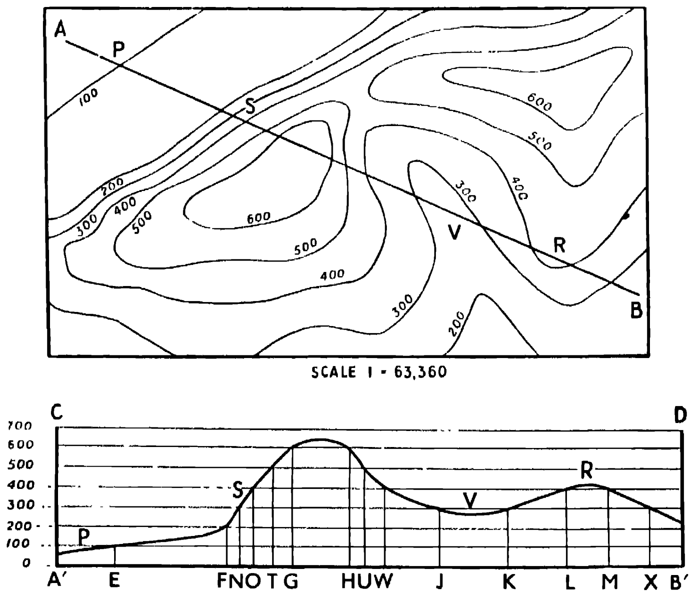


Fig. 4.

carefully all the points at which AB is crossed by contour lines. Place the edge of the paper along the line A′B′ and mark the contour points on this line. At each of these points E, F, G, etc., erect a vertical. The vertical line at E corresponds to the point where 100 ft contour crosses AB on the map. Therefore put a dot on this line where it is crossed by the horizontal line for 100 ft. Continue this process, being careful to note that at G and H, J and K, and L and M, neighbouring contours are of equal height. Join up the dots.

Between G and H it is obvious that the section line must be carried above 600 ft, but it must not touch 700 ft. In the same way the line between J and K must dip but must not touch 200 ft. The section thus drawn reveals the chief relief features of the map, viz. a plain (P), a steep slope (S), a valley (V), and a ridge (R). It should be noted that while the horizontal scale is 1 in. to 1 ml., 1 : 63,360, the vertical scale is $\frac{1}{10}$ ft to 100 ft, *i.e.* 1 in. to 1,000 ft, or about $5\frac{1}{4}$ in. to the mile. In other words the vertical scale is exaggerated about five-fold in relation to the horizontal scale.

Similar methods are used for drawing profiles of roads and rivers. But as these are not straight lines the lengths of the road and the horizontal intervals between the contours must be measured separately with a piece of cotton or string. The effect of this is to straighten out the road or river, and to give its slopes in relation to its full length.

EXERCISES

1. Draw a section from Rackham (0413) to Burpham (0408).

2. Draw a section from Camp Hill (0311) through South Stoke (0210) to the letter "l" of "Arundel" (0109).

3. Draw a section of the Lavant Valley [take an east to west line through Preston Farm (8511)].

4. Construct a profile of the main road between Petworth (9721) and Petworth station (9619).

5. Construct a profile of the main road between Singleton (8713) and Cocking (8717).

6. Construct a profile of the main road between Upwaltham (9413) and Duncton (9517). Why is one section of this road so winding?

7. Draw a profile of the hill-top road from Linch Down (8417) to Bishop's Ring (9515).

8. Draw a section from Glatting Farm (9714) to the word "Slindon" (9608).

Intervisibility of Places

It is often an advantage when reading a map to know whether one place can be seen from another and vice versa.

This can usually be determined by an examination of the contours.

(1) Where the contouring shows a convex slope (see HK, Fig. 11) the top of a hill is not visible from the foot of the hill.

(2) Where the contouring shows a concave slope (see LM, Fig. 11) the summit and foot of a hill are intervisible. It must not be forgotten, however, that minor eminences, woods and buildings may obscure the view of a point which by consideration of the contours alone would appear to be easily visible.

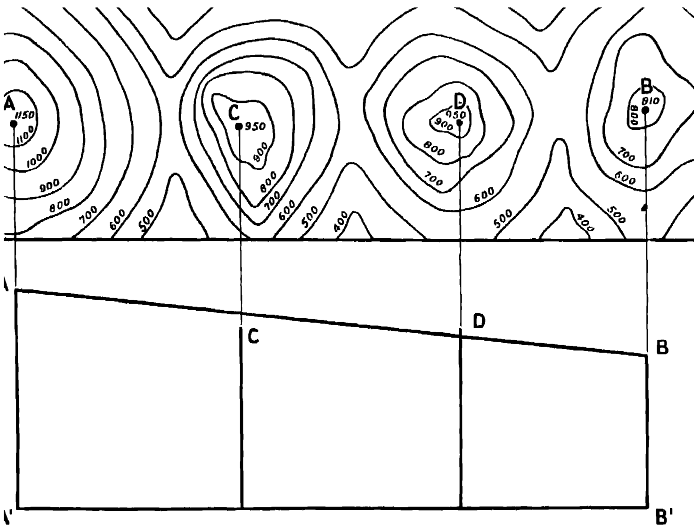


Fig. 5. One Method of Determining Intervisibility.

(3) Two points of the same height are intervisible if there is no higher land between them.

(4) Two points of unequal height *may or may not* be intervisible if there is no land intervening which rises above the level of the higher of the two points. In such examples the easiest way to determine whether the points are intervisible or not is to draw a "Skeleton Section".

Example. Are the points A and B on Fig. 5 intervisible?

This figure shows four hills: A, B, C, D. Neither C nor D are higher than A, but both are higher than B. Join AB,

and pick out the highest points on this line betwen A and B. These are C and D. Draw a line A′B′ equal in length to AB. At A′ erect a perpendicular to represent 1,150 ft on a scale of $\frac{1}{10}$ in. to 100 ft, *i.e.* 1·15 in. At a distance AC from A′ erect a perpendicular to represent the height of hill C, viz. 950 ft (the line will be 0·95 in.). At a distance AD from A′ draw a perpendicular to represent the height of hill D (*i.e.* 0·95 in.). At B′ mark off a line (0·81 in.) to represent the height of hill B. Join AB on the skeleton section. It will be seen that although hill C does not rise above the line, the hill D does and so blocks the view. A and B are therefore not intervisible.

EXERCISES

1 Is Bignor Hill (9813) visible from the Roman Villa (9814)?

2. Is the point 515 (8812) visible from Levin Down (8813)? If so, why?

3. Is the highest point of Barlavington Down (9615) visible from the inn at Duncton (9617)?

Views

Example. Describe the view looking south from the point 960218 on the main road at Tillington.

"In the foreground is a farm beyond which are fields, with very little woodland, sloping southwards to the river valley. Beyond is a belt of undulating land, heavily wooded, which rises to a forested scarp with an even sky line."

In writing a description of a view, care should be taken to bring out the *salient* features and to avoid long descriptions of too many details. It should be remembered that trees, buildings, and even gentle slopes obscure the view of objects clearly marked on the map. For instance, in the above example, neither river nor railway is visible because each lies in a hollow.

EXERCISES

1. Describe the view looking S.E. from the Inn at Watersfield (0115).

2. Describe the view from the gate to Cowdray Park (8922) looking towards Cocking (8717).

3. Describe the view looking south from the tower of Arundel church (0107).

Gradients

By a study of the contours and spot heights on a map it is possible to ascertain the gradient or slope of hillsides, roads, etc. To find the average gradient between two points on a map it is necessary to know (*a*) the height of both the places, and (*b*) the distance between them.

Example. On the given map what is the average gradient of the road between the cross-roads at Pulborough (0418) and the inn on Codmore Hill (0520)?

Height at inn above sea-level (by spot height) is ... 158 ft.
Height at cross-roads above sea-level (by contour) is 50 ft.
Difference in height between the two places is ... 108 ft.
Distance between the two places is 1·15 ml. by measurement.
There is therefore a rise of 108 ft in ... 1·15 ml.
There is therefore a rise of 108 ft in . 1·15 × 5280 ft.
There is therefore a rise of 1 ft in . . $\frac{1\cdot15 \times 5280 \text{ ft}}{108 \text{ ft}}$.

∴ There is rise of 1 ft in 56 ft (approximately).
The gradient is 1 in 56.

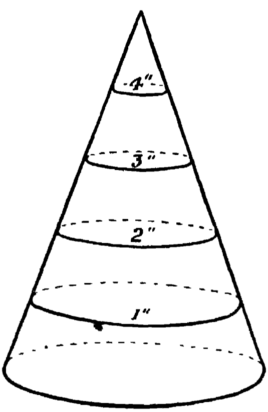


Fig. 6.

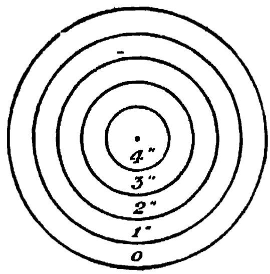


Fig. 7.

Exercises

1. What is the average gradient of the hillside between the figure 135 on the main road (0513) and the figure 636 on Rackham Hill (0512)?

2. What is the average gradient of the main road between the road junction at Westhampnett (8806) and Warehead Farm (9108)?

3. What is the average gradient of the road between the road junction in Houghton (0111) and the cross-roads near Whiteways Lodge (0010)?

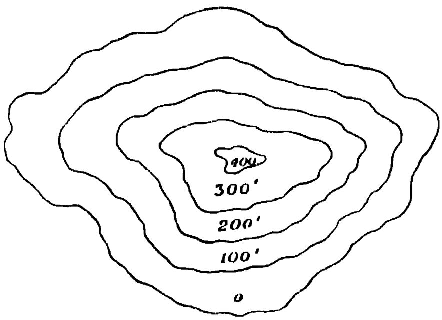


Fig. 8.

4. Find the average gradient of the railway between the station at Mid Lavant (8508) and the south end of the railway tunnel (8716).

Some Typical Contour Forms

Since contours are so generally used to show relief on O.S. maps it is necessary that the contouring of the chief types of relief features should be easily and quickly recognised.

If lines are drawn round a cone (Fig. 6) so that the first is 1 in. above the base all the way round; the second 2 in., and so on, then viewed from above the lines would appear as concentric circles (Fig. 7). This would be a contour map of a cone. Fig. 8 represents a contour map of an island rising from the coast to hill just over 400 ft high.

Fig. 9 represents a hilly ridge rising to over 400 ft. On the west the hill rises 300 ft in the distance AB, but on the east of the ridge the land rises 300 ft in the longer distance DE.

It is clear then that the western side of the ridge is steeper than the eastern side. Contours drawn closely together denote steep slopes, and those farther apart denote gentle slopes. Such a ridge is known as an escarpment or scarped ridge. The western slope is known as the *scarp slope*, and the eastern slope as the *dip slope*. Contour lines cannot cross one another, but at LF the 200 ft contour meets the 100 ft contour and the two are coincident for a short distance. This indicates that the slope is so steep that there is a vertical cliff at least 100 ft high. Coastal cliffs are shown by contours in this way. Between the points O and P it is possible to cross the ridge without climbing to a height of 300 ft, while to cross the ridge further north or further south it would be necessary to climb over 400 ft. Such a feature is known as a *col* or *saddle* (C). The dotted line XY represents the watershed. Some of the rain which falls on the ridge flows down the western slope and some down the eastern slope. The watershed is the line joining all the highest points so dividing the eastern drainage from the western drainage. The points (heavily dotted on Fig. 9) at which the watershed crosses each contour should be very carefully noted.

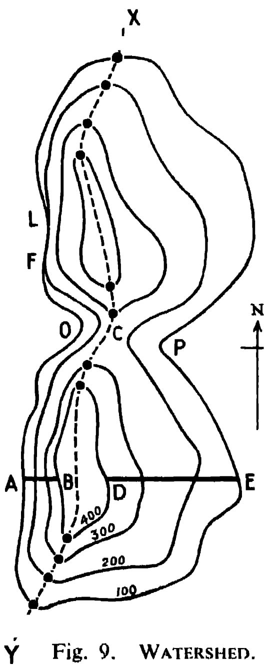


Fig. 9. Watershed.

Find on the given map as many examples as possible of scarped slopes, cols, and dip slopes. For guidance there is a col where the main road crosses the highland to the south of Cocking (8717). A careful search will reveal other examples.

Figs. 10 (*a*) and 10 (*b*) show two contour sketches of very similar V-shaped contours, but the numbering of these contours is different. Although at first sight they appear similar, these two diagrams represent totally different relief features. In Fig. 10 (*a*) the shaded region X is *higher* than the surrounding

land, but in Fig. 10 (*b*) the shaded region Y is *lower* than the surrounding land. Fig. 10 (*a*) represents the end of a hilly ridge or ***Spur***, but Fig. 10 (*b*) represents part of a river valley. In Fig. 10 (*a*) the drainage would flow outwards as shown by the dotted lines, but in Fig. 10 (*b*) a river flows down the middle. The points (heavily dotted) at which the river crosses the contours should be carefully noted. *The V's of a river valley (re-entrant contours) point towards the source of a river.*

Fig. 11 (*a*) shows a river valley with numerous tributaries. In the upper courses of the tributaries, which are swift flowing, the contours cross the streams at short intervals. In contrast, in the slower lower course of the river, where it flows over a

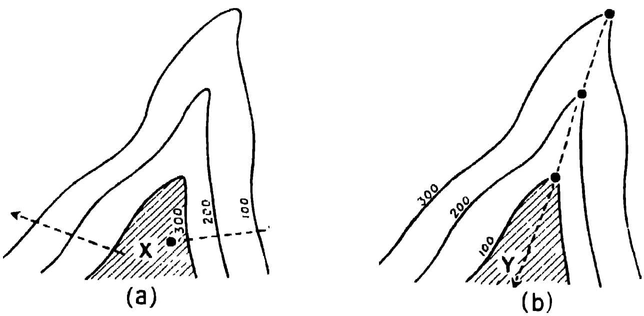


Fig. 10. (*a*) A SPUR. (*b*) A VALLEY.

Draw sections of these diagrams through X and Y.

flat plain, the contours cross the river at more widely spaced intervals. The fall of the river between X and D is only 100 ft in contrast to the fall of 400 ft between the points E and F in the tributary valley. S is an example of a hill spur, and there are coastal cliffs and a headland between A and B. The tributary XY flows through a narrow steep-sided gorge. This is shown by the closeness of the contours on the valley sides. This map also illustrates another important point. Two lines HK and LM are marked. In walking from H to K you would rise quickly at first and then slowly as illustrated by Fig. 11 (*b*). This is a *convex slope*, and is indicated by contours close together at the lower levels, and widely spaced at the higher levels. It is clear from Fig. 11 (*a*) that the point

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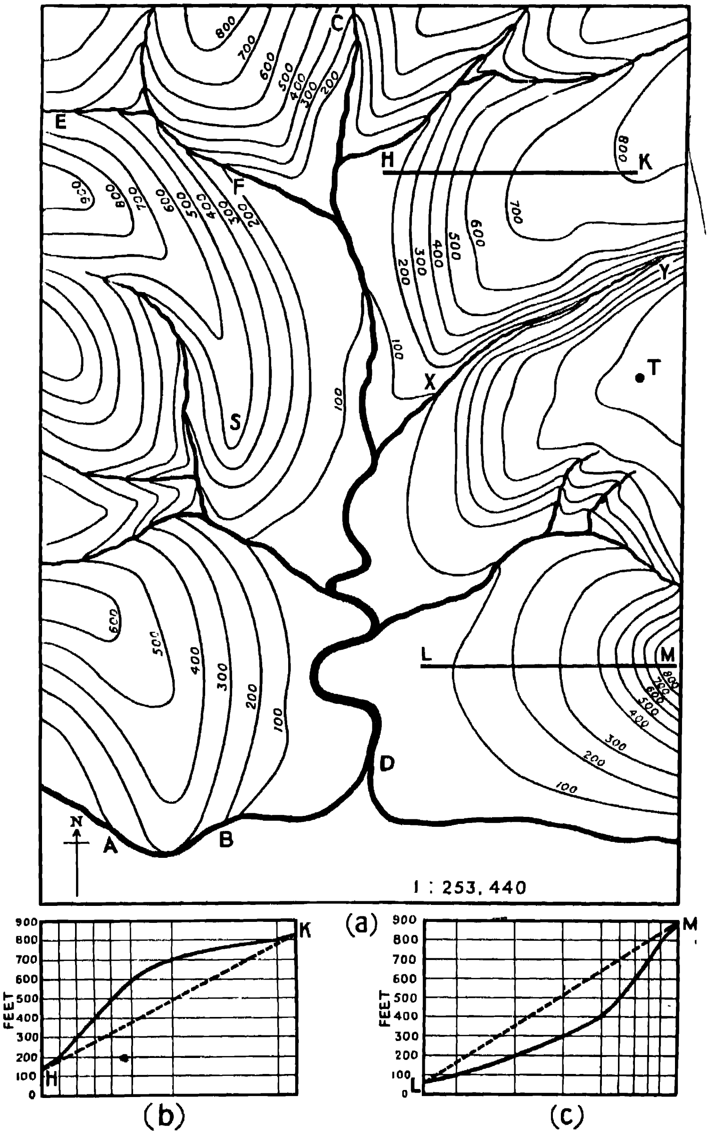


C
E
F
H
K
S
X
Y
T
L
M
D
A
B
N
800
700
600
500
400
300
200
100
1 : 253, 440
(a)
900
800
700
600
500
400
300
200
100
0
FEET
H
K
(b)
L
M
(c)

Fig. 11.

K would not be visible from H as it is obscured by the brow of the hill. On the other hand, if you walked from L to M you would rise slowly at first and then quickly. This is a *concave slope* as illustrated on Fig. 11 (*c*). It is indicated by the contours being widely spaced at the lower levels and close together at the higher levels. The point M would be visible from L.

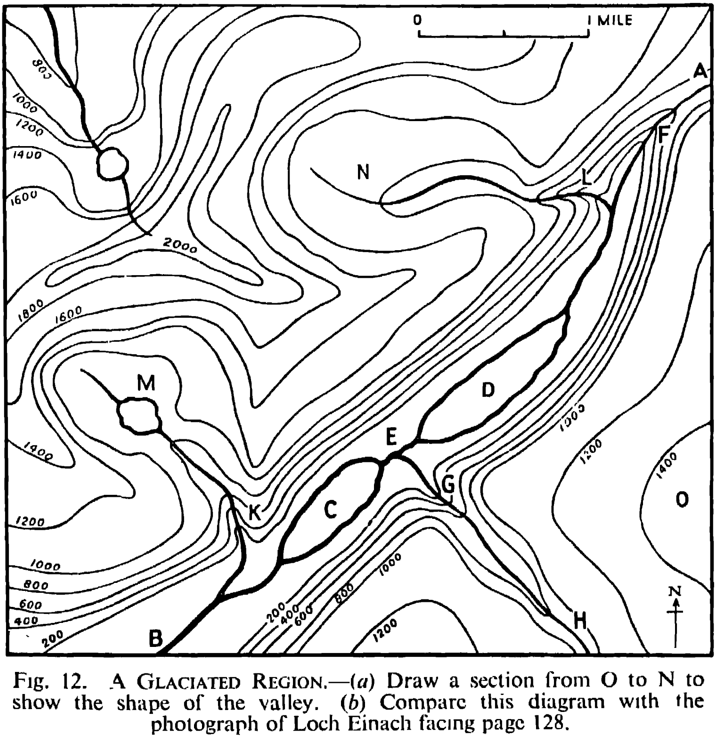


Fig. 12. A Glaciated Region.—(*a*) Draw a section from O to N to show the shape of the valley. (*b*) Compare this diagram with the photograph of Loch Einach facing page 128.

Fig. 12 shows some of the principal features of a glaciated region. Before we study this map, pages 123 to 128 should be read carefully. From A to B is a long U-shaped valley with steep sides and a flat valley floor. This valley contains two long, narrow ribbon lakes which were formerly joined but which have been separated by a belt of alluvium deposited

by the swift tributary from the S.E. At F the contours show that the main stream falls very quickly for a short distance. Such a "step" in the valley floor is characteristic of many glaciated valleys. Above the 1,000 ft contour the valley sides

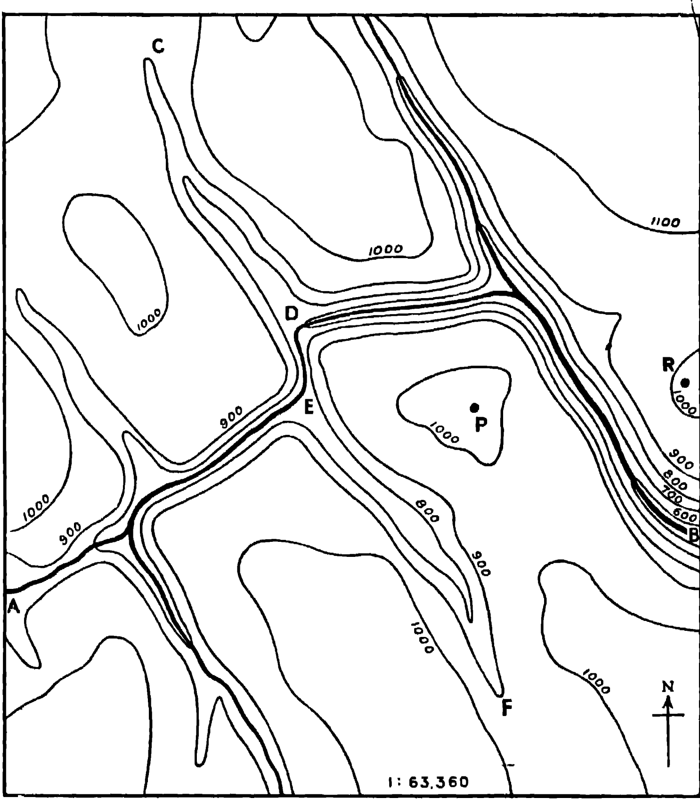


Fig. 13. A LIMESTONE PLATEAU.—Draw a section from P to R and contrast it with the section drawn for Fig. 12.

begin to slope more gently giving the "shoulder" outline of the valley sides. The tributary valley GH is a *hanging valley*. Between H and G the stream flows gently along its valley, but north-west of G it flows swiftly, probably with falls or rapids in its course, to the main valley floor. Similar rapids

are denoted on other tributaries near K and L. M is a mountain tarn set in a flat-bottomed, steep-sided, and roughly circular basin. This basin is an example of a *cirque*, *corrie*, or *cwm*. A similar relief feature is shown at N, but there is no tarn. Here the stream has lowered its level sufficiently for the tarn to be drained away. In the region O the widely-spaced contours show the typical rounded tops of mountains that have been under a sheet glacier (page 125).

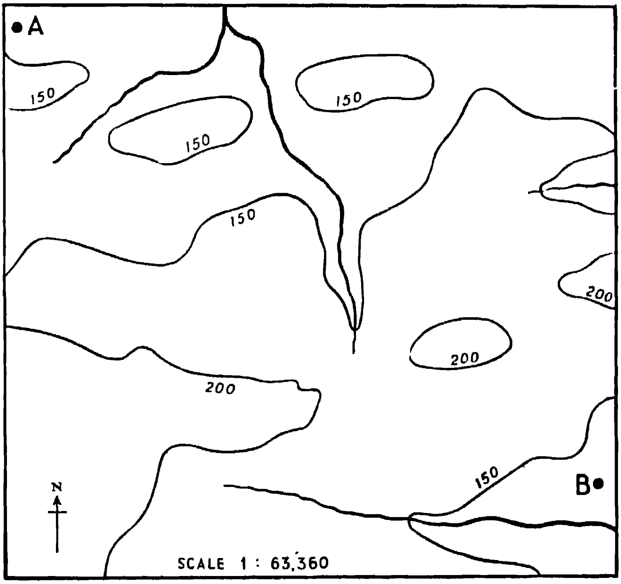


Fig. 14. AN UNDULATING PLAIN.—Draw a section from A to B. This will reveal the undulating character of the surface.

Fig. 13 illustrates the features characteristic of a limestone plateau such as may be found in the Southern Pennines. It shows a river flowing from A to B in a deep steep-sided valley. This valley differs from the glaciated valley because it is not flat-bottomed. The tributaries are also set in deep valleys, but some of the tributary valleys, *e.g.* CD and EF, contain no streams. These are *dry valleys*, the absence of streams being due to the porous nature of the limestone.

Above 900 ft the contours are widely spaced and the slopes gentle. This is the plateau. Because the streams have cut deep valleys into the plateau it is known as a *dissected plateau.*

Fig. 14 represents the contouring of a lowland area. There are no steep slopes and the land surface rises and falls slowly. This is an example of a portion of an undulating plain.

While studying Fig. 15 it would be advisable to refer to Fig. 17. This contoured diagram represents a broad valley

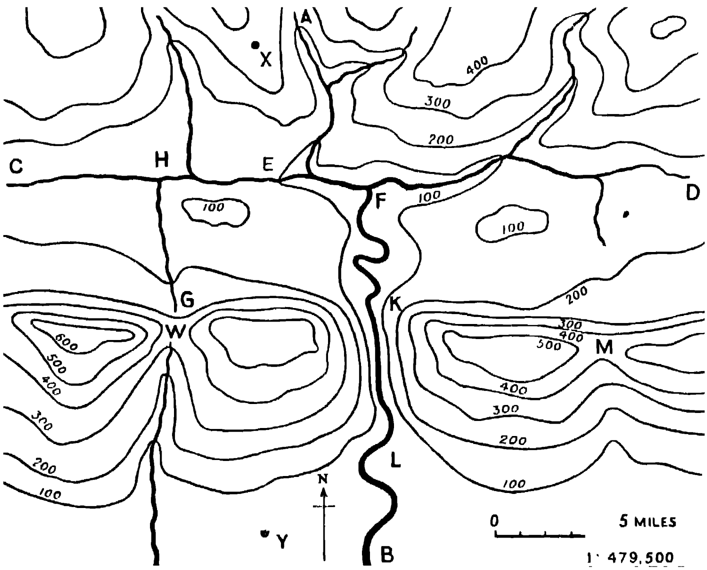


Fig. 15. A SCARPED RIDGE AND CLAY VALE.—Draw a section from X to Y.

(a longitudinal valley) between a hilly district to the north and a scarped ridge to the south. The main river A to B is a consequent stream, while CE and DF are subsequent tributaries. The small tributary GH is an obsequent stream. The whole drainage system illustrates river capture. At W there is a *wind gap*, while the deep break in the ridge between K and L is a water gap (see plate facing page 32). At M is an example of a col or saddle. This contoured diagram is

especially important because features are in many ways similar to those of the O.S. map at the end of this volume.[1]

The Interpretation of the Relief Features of the Given Map

Draw a rectangle measuring 6 in. by 5 in. and divide it into 1 in. squares, each of which corresponds to a square of side 4 km. on the map. Mark round the edge the grid numbers corresponding to those on the map. Omitting all the minor curves, sketch into the framework, square by square, the main outline of the 250 ft contour. Then lightly shade all the land which is over 250 ft above sea-level. Print the word "steep" along the steepest side of the chief hilly region. Then insert with a blue pencil the River Arun (paying particular attention to the large meanders) and its tributary the River Rother, the River Lavant, and the small stream draining north from Cocking to Midhurst. On this sketch mark also (in red) Chichester, Arundel, Cocking, Midhurst, Petworth, and Pulborough. The finished drawing should be similar to, but larger than, Fig. 16.

The outstanding features of the map are now revealed in a simplified form. It is apparent that the surface features of the given map consist in the main of a central ridge of hilly country with a scarp slope to the north, and dip slope to the south. South of the ridge is a flat plain, and north of the ridge a wide east to west valley drained by the River Rother. North of this valley the land begins to rise again. The ridge is broken by a water gap through which flows the River Arun, and ten miles to the west of this gap is a wind gap south of Cocking. From this point a small stream flows north to Midhurst, while two miles south of the Cocking Gap the River Lavant flows southwards to Chichester. At this point a comparison of these relief features with those on Fig. 14 would be profitable. Which of the rivers on the Chichester map may be termed consequent, subsequent, or obsequent?

Follow the Arun and Rother Valley to the point where the 50 ft contour crosses the stream (9220). Measure the length of the river from this point to the mouth of the Arun (the Arun

[1] Where there is difficulty in visualising the relief shown on the preceding diagrams 8-14 inclusive, it is suggested that tracings of these diagrams should be made and cardboard models constructed by superimposing on one another, in the correct position, layers of cardboard cut out in the shape of each successive contour.

enters the sea two miles beyond the southern limit of the map). From these data work out the gradient of the river between South Ambersham (9120) and the sea. This section of the river flows very slowly, hence the Arun meanders in great loops from Pulborough southwards. In the Arun Gap (Amberley to Arundel) the river, on the outside of the meanders, has in many places cut into the valley sides exposing white chalk cliffs, *e.g.* to the west of North Stoke where the

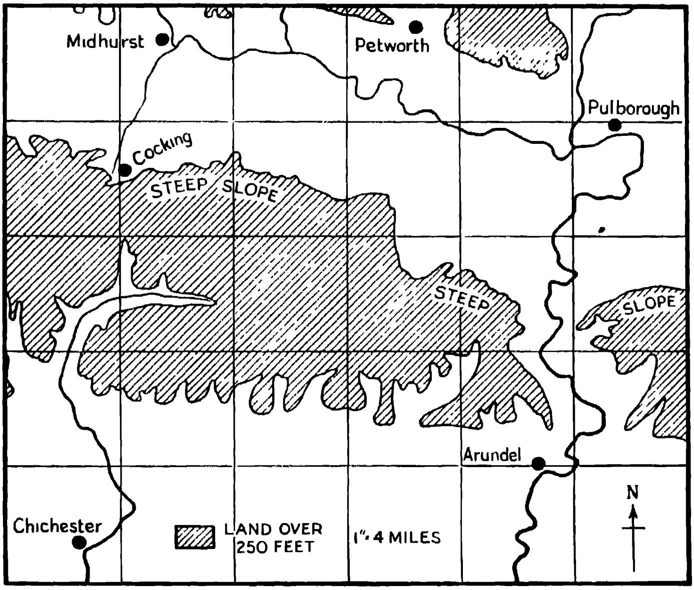


Fig. 16. Distribution of Highland and Lowland.

contours form almost a semicircle. As a comparative exercise, work out the gradient of the River Lavant south of West Dean. This stream flows more quickly than the River Arun and does not meander so much. The Lavant south of West Dean is a very small stream, relative to the size of the valley through which it flows. Can you give the reason for this?

The central hilly district of the map, being part of the South Downs, is composed of chalk. Because chalk is a porous rock there is little surface drainage and many dry valleys

which may, however, contain streams for a short period in rainy weather. (See Plate 6.)

A simple diagrammatic section from the north to the south of the map is given in Fig. 17. To the south of the chalk hills is a fertile clay plain, while to the north is a plain composed of Gault Clay and Greensands.[1]

The Vegetation of the Map

There is little direct information given on the map concerning the vegetation of the region, but much may be deduced from other features and a knowledge of the rocks. A comparison of this map with the "Land Utilisation" map of the same area would be valuable.

The dark green regions are woodlands, coniferous or deciduous according to the trees indicated. The light green

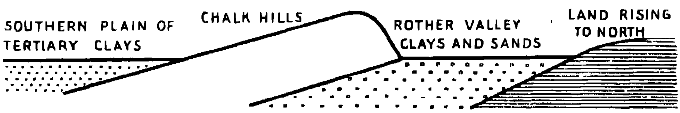


Fig. 17. A Diagrammatic Section Across the Map from South to North.

areas are parks. Other information may be deduced from the names of places, *e.g.* Oakwood House, Graffham Common, Downs Farm, etc.

The chalk hills to the west of the Arun Gap have many extensive woods of coniferous and deciduous trees. This is somewhat contrary to the generally accepted idea of a chalk downland, but here much of the chalk is covered with a layer of "clay with flints" which holds up the surface water and encourages tree growth. The chalk hills east of the Arun Gap are devoid of woodland. Here the porous chalk is at the surface, and there is a large area of typical grassy downland, a region eminently suitable for sheep rearing. South of the chalk hills are few woods, but a very large number of farms. This suggests that the original forest of the clay plain (see Fig. 17) has been cleared because the land is fertile and very suitable for agriculture. It is a region of mixed farming, growing grain and fruits and rearing cattle for dairying.

[1] See Preece and Wood, *The British Isles*, pages 164-5.

Immediately north of the escarpment between Bepton (8518) and Graffham (9216) around Sutton (9715) and Bignor (9814) and east of Amberley (0213) is a narrow belt containing no woodland and many farms. This, too, is a region of agricultural wealth. The upper Greensand rocks, which here come to the surface, are rich farming lands. Here a considerable number of fields are used for the cultivation of wheat, barley, turnips, etc. The arable areas of this zone are marked brown on the "Land Utilisation" map of the region.

Immediately to the north of this belt is a region of rich pasture land associated with the heavy soils of the Gault Clay belt. Still further north, and to the south of the River Rother, is a region where large areas of coniferous woodland still remain. Coniferous trees flourish on light sandy soils, and it is therefore to be assumed that in this region the soil is not sufficiently fertile to have encouraged the clearing of the natural woodland.

North of the River Rother the soil is richer, for there again are fewer trees and more farms, primarily engaged in dairying.

The districts near the river from Pulborough southwards are badly drained, the frequent fine blue lines indicating drainage ditches. These districts are too wet and marshy for arable farming and are used as water meadows for cattle rearing. Many of the fields contain large patches of rushes.

The Distribution of Settlements

(A) Towns.—The most important towns on the map are Chichester, Arundel, Midhurst, and Petworth.

Chichester. Chichester (plate facing page 33) is a cathedral city built on the site of a Roman settlement (Regnum). In the Town Hall a Roman temple inscription is preserved, two of the churches are built on Roman foundations, and near the city is the site of a Roman amphitheatre. A careful study of the roads of the city shows a "ring" (coloured yellow) which is a road encircling the line of the city walls of Roman foundation. The main roads from north to south and east to west cross one another in the centre of the city to form a "Carfax" (Lat. *quadrifurcus* = fourforked, cf. Fr. *carrefour*). Here at the junction of North, South, East, and West Streets stands a fine old market cross, and nearby is the cathedral (see Fig. 18). The occurrence of the market and church at the

central cross-roads is a common feature of many old market towns (*e.g.* Chester, Shrewsbury, Oxford), though in modern times the market may have been established on another site.

Chichester is situated where two natural routes cross: (*a*) the east to west route along the southern plain, and (*b*) the north to south route via the Lavant Valley and the Cocking Gap across the chalk hills to the north. This is the most

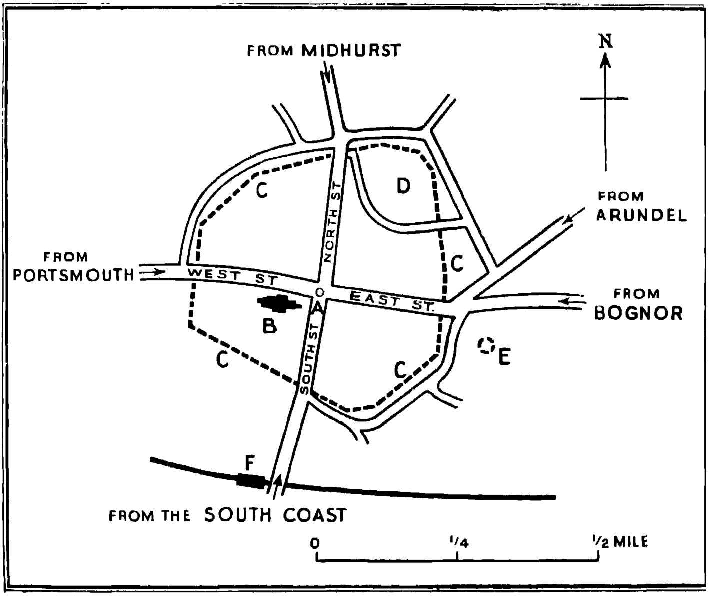


Fig. 18. PLAN OF CHICHESTER.—A Carfax (cross-roads) with old market cross. B. Cathedral. C. City walls of Roman foundation. D. Priory just within the walls. E. Site of Roman amphitheatre. F. Railway station outside walls (cf. Chester, York, and Shrewsbury). Compare this diagram with the diagram of the site of Shrewsbury.

important fact of its position both in Roman and modern times. Roads and railways follow these natural routes so that Chichester is an important nodal centre. Striking north-east from Chichester is the Roman road Stane Street, which can be followed, sometimes as a road, and sometimes as a footpath, as an extraordinary straight line to beyond Pulborough (0418). That Chichester is a city of some regional importance is

emphasised by the existence of a cathedral and a college. To-day its main function is as a route centre, and as a market centre for the surrounding agricultural lands.

Arundel. Like Chichester, Arundel is important because of its relation to natural routes. It is situated on the lower hill slopes above the badly drained land of the valley floor. At the southern entrance to the Arun water gap it controlled a natural route northwards between the south coast and London. For this reason it was fortified in Norman times to protect this route against possible invaders from the south. The site of Arundel Castle was suitable for defence because it rose above the surrounding lowland and because at this point the river flowed along the foot of the hills and acted as a natural moat. (See plate facing page 33.)

Although there is a continuous route (road and footpath) through the Arun Gap between Arundel and Amberley, the main route northwards avoids the valley and keeps to the higher land. This is partly because of the marshiness of the valley and partly because of the number of bridges required. The railway has had to follow the valley, in spite of bridging and other difficulties, in order to avoid the steep gradients of the hills on either side. Arundel is a route centre of some importance, and acts as a market town for the surrounding country. Small sailing boats can reach Arundel from the sea.

Midhurst. Midhurst (hurst = wood) is a small market town. It is situated at the intersection of the east to west route along the Rother Valley, and the north to south route to Chichester via the Cocking Gap. It is the limit of navigation on the Rother for small rowing boats and canoes.

Petworth. This is another small market town. Like Midhurst, it is situated where an east to west route crosses a north to south route. To the south runs a moderately easy route across the chalk hills to Chichester, while to the north the road follows a valley in the northern hills to Guildford and London.

(B) VILLAGES.—Draw another map similar to Fig. 16, and on it, square by square, mark all the villages (groups of houses with a church). The finished diagram will throw much light

on the distribution of villages in relation to the relief. They fall into several groups—

(1) A line of villages to the north of the River Rother, including Stedham (8622), Tillington (9622), Fittleworth (0019), etc. These settlements owe their existence to:—

(*a*) Fertile soils for farming.

(*b*) Easy east to west routes along the northern edge of the Rother Valley.

(*c*) The control of minor routes northwards across the hill country beyond the northern limit of the map.

All these villages are linked by an important east to west main road.

(2) There is a second line of villages along the northern edge of the escarpment. These include Bepton (8518), Cocking (8717), Heyshott (8917), Graffham (9216), Sutton (9715), Bignor (9814), Bury (0113), and Amberley (0213). These villages owe their existence to:—

(*a*) The occurrence of rich farm lands, and

(*b*) Water supply.

South of these villages is the chalk country. Rain soaks through the porous rock until it reaches an impermeable layer. Along the junction of the permeable and impermeable rocks is a line of springs.[1]

The points where the small north-flowing tributaries of the Rother begin should be observed. These villages are linked only by minor roads and footpaths, but each is connected by a second class road with the main east to west road at the north of the map.

(3) South of the chalk hills on the southern plain there are a large number of villages due to the fertility of the land and the ease of obtaining water supplies.

(4) A fourth group of villages are those along the margins of the Arun Gap, *e.g.* Houghton, North Stoke, South Stoke, etc. It will be noticed that all these villages are on the higher land near the valley sides above the level of the marshy valley floor (cf. Arundel).

[1] See section on springs, page 117 and Fig. 69.

(5) Another group of villages is to be found in the Lavant Valley, *e.g.* West Dean, Singleton, and East Dean. Their position is primarily determined by their position on the north to south valley route, and their control of the lateral routes which enter the Lavant Valley from the east and west. Water supplies would be obtained by boring through the chalk layers, which at this point (because of the lower elevation) will not be as thick as on the higher chalk lands.

Study Fig. 16 and find out how far it is true in this region that the large market towns tend to occur at intervals of about ten miles. Can you think of any possible reason for this?

It should be noted finally that the villages are essentially lowland settlements, seeking the fertile lowlands and avoiding the uplands. Only two villages, Upwaltham (9413) and Madehurst (9810) occur above a height of 250 ft.

Communications

Prepare another map similar to Fig. 16, and on it mark the following in addition to the rivers (in blue): —

(*a*) The main roads (in red), Chichester to Midhurst, Chichester to Arundel, Chichester to Petworth, Arundel to Pulborough, and Midhurst to Pulborough.

(*b*) The railways (in black), Chichester to Midhurst, Chichester to Arundel, Arundel to Pulborough, and Pulborough to Midhurst.

Ignoring the road from Chichester to Petworth, it will be observed that both the roads and railways are arranged in a definite rectangular pattern. Midhurst, Pulborough, Arundel, and Chichester are at the four corners of the "communication rectangle". This is because of the strong control of the relief features on the routes. East to west routes (both rail and road) follow the north and south lowlands. North to south routes take advantage of the easiest routes across the escarpment.

In both the northern and southern lowlands the road and rail routes are some distance apart. In each region the railway route keeps to lower land than the road, in order to avoid gradients which would be too steep for a railway. The villages were linked by roads long before the period of railway building.

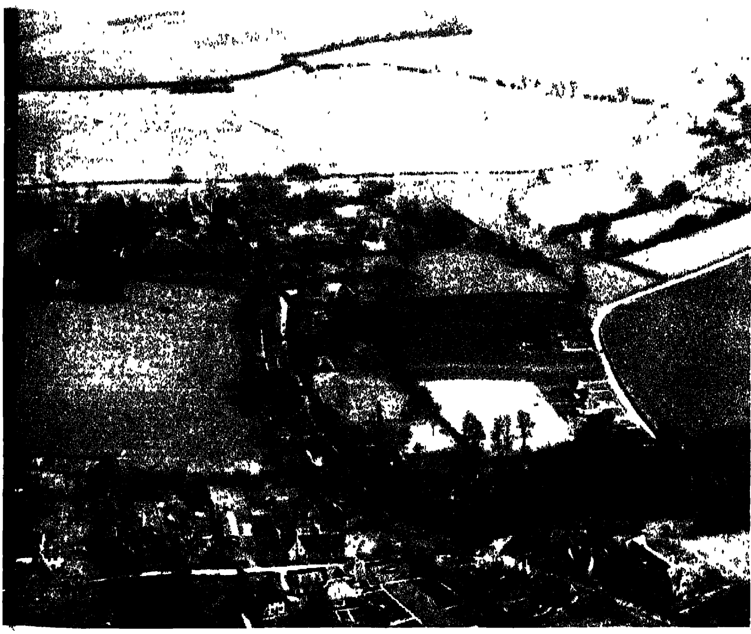


PLATE 3

Above: View from Bury Hill (004122) looking north-east across the northern end of the Arun Gap through the South Downs (Point K in Fig. 15). Identify the principal features on the Ordnance Map and note particularly the lime works. (*Geological Survey, Crown Copyright Reserved.*) *Below:* Bury Village (0113). The river meander is here close to the western margin of its flood plain. Compare with the Ordnance Map and note the drainage ditches in the flood plain. (*Aerofilms Ltd.*)

PLATE 4

Above: Arundel, a bridge-town, and its castle. The ruins of an earlier castle can be seen just to the right of the bridge. Compare the contours with the map. (*Aerofilms Ltd.*)

Below: Chichester, a crossroads-town. Compare this picture with the Ordnance Map and with Fig. 18. (*Aerofilms Ltd.*)

The study of the course of the Rivers Rother and Arun reveals a number of old canals and locks (*e.g.* in square 0218). This suggests that at some period the river has been used for transport. Beyond the northern limits of the map is the Wealden Area, where, before the Industrial Revolution, there was a flourishing iron industry. This partly helps to account for the former importance of river transport. Can you suggest why?

Probably the most interesting feature of the communications shown on the map is the Roman road (Stane Street) which trends north-eastward from Chichester. It is used as a modern road as far as Warehead Farm (9108). At this point the modern road bends around Halnaker Hill to avoid the higher land. The Roman road, however, used to proceed direct to Seabeach, irrespective of the high ground which had to be crossed. Beyond Seabeach the course of the Roman road can be traced almost continuously to Pulborough and beyond, but large stretches of it have fallen into disuse and can only be followed as a footpath.

EXERCISES

1. Account for the fact that the railway stations for Fittleworth (0019) and Petworth (9721) are so far removed from the villages.

2. Compare and contrast the road and railway routes between (*a*) Arundel and Pulborough; (*b*) Chichester and Cocking; (*c*) Chichester and Arundel. Account for the differences.

3. What difficulties are encountered on the main road between Slindon (9608) and Whiteways Lodge (0010)?

4. Account for the fact that so many of the roads of the chalk uplands are unfenced, while there are so few unfenced roads on the lowland areas.

5. Is there any section of a main road with a gradient steeper than 1 in 7 (consult characteristic sheet, opposite page 4)?

The Distribution of Population

Prepare another diagram similar to Fig. 16. On it mark: (*a*) each village (with a church) by a small square; (*b*) each hamlet (a group of houses without a church) by a small circle; (*c*) each farm by a small cross.

The completed diagram will give a very good idea of the general distribution of population throughout the area. The following facts will be revealed:—

(1) The southern plain, a rich agricultural region, is densely peopled.

(2) The middle belt of highland is scantily populated. This is due to:—

(*a*) The prevalence of woodland.

(*b*) The large areas of chalk downs which are only suitable for sheep farming.

(*c*) The difficulty of obtaining supplies of water owing to the porous nature of the chalk.

(3) Within the middle belt of highland the Lavant Valley and the Arun Gap are somewhat more densely populated.

(4) The broad vale north of the chalk escarpment is densely but not evenly populated. Population is densest along the northern and southern margins of the vale, and there is a middle zone (corresponding to the region of coniferous woodlands) with a less dense population. Even this, however, is not so scantily populated as the chalk hills.

(5) The area between Pulborough and Amberley, bounded on the east and west by the main roads A.283 and A.29 respectively, contains few people. Think of as many reasons as possible why this area is scantily populated.

Historical Remains and Evidence of Former Settlement

Prepare another map similar to Fig. 16. On it mark: (1) in black, all Roman remains, including Stane Street; (2) in red, all tumuli and non-Roman camps and entrenchments (if any); (3) in blue, all other antiquities.

(1) The Roman remains consist of those at Chichester and a series of entrenchments and a camp in the neighbourhood of that city. These were part of the defensive system of the

main Roman settlement at Chichester. There is another camp near Stane Street (0217). This camp, near the confluence of the Rother and Arun, guarded the routes southward via the Arun Gap, and westwards up the Rother Valley. The Roman villa at 9914 is also near to Stane Street.

(2) The tumuli or burial mounds, and non-Roman camps and entrenchments are remains of the British period of occupation. The early inhabitants of Britain avoided the marshes and forests of the lowlands, therefore most British remains are found on the higher land. This is certainly true of the British remains shown on the specimen map. In square 9209 is a British camp occupying the summit of a small hill. British camps are nearly always to be found in such a position, and perhaps one of the most complete and well known is the British camp on the Malvern Hills. These camps usually consist of an embankment, or a concentric series of embankments, composed of rock and earth dug from encircling ditches.

British settlements were usually connected by tracks following the hill tops. Because of this they are often indicated as "Ridgeways". On the specimen map there is a ridgeway following the crest of the escarpment from Linch Down (8417) to Bishop's Ring (9515). Try to find other portions of this Ridgeway further east. Nearly all the tumuli marked on the map are near to this ancient track.

In some parts of Britain there are other evidences of the early British period, such as entrenchments (non-Roman) and stone circles such as Stonehenge. Stone circles are more commonly found in the highlands of Cornwall and Devon, the Welsh borderland, and the Lake District.

(3) There are not many indications of other historical remains on the map, and they consist of (*a*) castles at Amberley (0213) and Arundel (0107); (*b*) a priory (0005); (*c*) four remains of what were probably Manor Houses, *e.g.* Drayton Manor House (8804). These remains are partly the result of the destruction of castles, religious foundations, and private property during the various periods of civil war in England. The mansion at Cowdray (8921) was accidently destroyed by fire in 1793. At Arundel, the Norman castle on

the hill is finely preserved and used as a residence, but there is a ruin of a Norman keep on the lower land by the river.

The Significance of Place Names

Some information concerning the history of a given region can often be deduced from the place names. Before the period of the Norman Conquest, Britain was invaded several times. The invaders left a lasting mark on the map of England in the form of the names they bestowed on the places where they settled. The most important groups of names are those (*a*) of Celtic origin; (*b*) of Roman origin; (*c*) of Anglo-Saxon origin; (*d*) of Danish and Scandinavian origin; (*e*) of Norman origin.

(*a*) NAMES OF CELTIC ORIGIN.—These are chiefly associated with Ireland, Scotland, the Lake District, Wales, Cornwall, Devon, *i.e.* the mountainous areas of the north and west to which the original inhabitants of Britain were driven by the successive invasions. Typical names of Celtic origin differ according to the parts of Britain in which they are found. The following list gives some of the commonest of the Celtic forms (I, Irish; W, Welsh; S, Scottish; C, Cornish): —

Aber (W), *mouth.*
Avon (W), *stream.*
Bal or Bally (I), *village, house,* or *farm.*
Bedd (W), *grave.*
Ben (S), *a peak.*
Bod (W), *abode.*
Bryn (W), *hill.*
Caer or Car (W), *fort.*
Cerrig (W), *stones.*
Carrick (I), *cliff.*
Coed (W), *wood.*
Combe (C), *valley.*
Croes (W), *cross.*
Cwm (W), *valley.*
Dol (W), *meadow.*
Dwfr (W), *water.*
Ferm (W), *farm.*
Glan (W), *shore* or *bank.*
Gwyn (W), *white.*
Hendre (W), *homestead.*
Inver (S), *mouth.*
Kil (S), *church.*
Knock (S), *hill.*
Llan (W), *church.*
Mawr (W), *big.*
Nant (W), *stream.*
Pant (W), *hollow.*
Pen (C), *peak* or *headland.*
Pistyll (W), *waterfall.*
Pwll (W), *pool.*
Pont (W), *bridge.*
Rhos (W), *moor.*
Tor (C), *high rock.*
Ty (W), *house.*
Ynys (W), *island.*

(*b*) NAMES OF ROMAN ORIGIN.—These are almost entirely confined to the use of the word "chester" (L. *castra*, a camp) and its variations, *e.g.* "caster" as in Lancaster,

"cester" as in Gloucester and Worcester, and "xeter" as in Exeter and Uttoxeter.

(*c*) Names of Anglo-Saxon Origin.—Such names are widely distributed over the lowlands of England and the lowlands of Scotland. They are particularly common in East Anglia and the southern counties. The following list gives some of the words which occur most frequently:—

Beck, *a rivulet.*
Borough, Burgh, Bury, *a fortified place.*
Dale, *a valley.*
Ham, *a house.*
Hurst, *a wood.*
Ing, *a field.*
Lea, *pasture.*
Marr, *a lake.*
Set, *settlement.*
Ton *or* Tun, *enclosure* or *village.*
Wick, *a village.*

(*d*) Names of Danish Origin.—Such names are most frequently found in (1) East Anglia, Yorkshire, and Northumberland; (2) Westmorland, Lancashire, and Cheshire. The most characteristic Danish termination is "by"—a village or homestead, which is evident in such names as Whitby, Appleby, West Kirby, and Derby.

The following are examples of Danish words which occur most frequently:—

Beck, *a brook.*
By, *a farm* or *village.*
Carr, *marshy ground.*
Fell, *a hill.*
Force, *a spring.*
Gill, *a ravine.*
Holme, *an island.*
How, *a mound.*
Lythe, *a slope.*
Nab, *a peak.*
Rigg, *a ridge.*
Scarth, *a pass.*
Thorpe, *a village.*
Toft, *a field.*
Wath, *a ford.*
Wick, *a bay.*
With, *a wood.*

(*e*) Names of Norman Origin.—These are not of very frequent occurrence, but when they do occur they are easily recognisable, *e.g.* Beaulieu, Richmond, Beaufort, etc.

Exercise

Study the place names on the specimen map and try to deduce some information concerning the settlement of the region in pre-Norman times.

General Contour Exercises

The drawing of contour maps from given data.

(*a*) Read the description carefully two or three times until you can visualise what is required.

(*b*) Make a small rough plan indicating where the chief features described will occur.

(*c*) Think out carefully how the rivers will be arranged, and draw these and their tributaries first. (This is most important if the finished map is to look like a possible piece of country.)

(*d*) Begin the contouring by drawing the lowest first and carrying it around the lower part of the rivers. Study the contouring on diagrams 8-14 and the contouring of selected O.S. maps in order to become familiar with the contour forms.

Draw contour maps of the following, taking care to insert a suitable scale, the numbers of the contours, and an arrow to indicate north:—

(1) A river valley with one tributary.

(2) A river valley with several tributaries.

(3) A lake surrounded by hilly country with all the rivers draining into the lake.

(4) A lake, long from east to west, lies in mountainous country. Rivers enter the lake on the north, east, and west; but on the south a stream flows from the lake, leaving it at a height of 300 ft.

(5) A plateau, 4 ml. long and 2 ml. broad, averages 1,000 ft in height. On the north it drops steeply to an undulating plain about 300 ft above sea-level, while in the south it falls gently to the coast.

(6) An island is 8 ml. long from north to south and 6 ml. wide. On it are two peaks, the one in the north being 1,000 ft high, and the one in the south 700 ft. The latter descends very steeply to the sea on the south. The col or pass between the two hills is between 300 ft and 400 ft above sea-level. On the north-west is a tract of marshy lowland, while the western slopes of the northern hill are heavily wooded. In the south-west is a village X with a post office and a church with a spire. On the east coast is another village Y, with a telegraph office,

a church with a tower, and a lighthouse. XY are connected by road and railway.

(7) Draw a contoured sketch map to represent the following tract of country which is 15 ml. from east to west, and 20 ml. from north to south. A range of hills about 5 ml. in width and with an average elevation of 700 ft has a general trend from west to east and presents a steep escarpment to the north. It is separated from the sea by a low coastal plain which gradually narrows eastward until the hills terminate in a bold promontory. The range is broken at one point by a gorge of

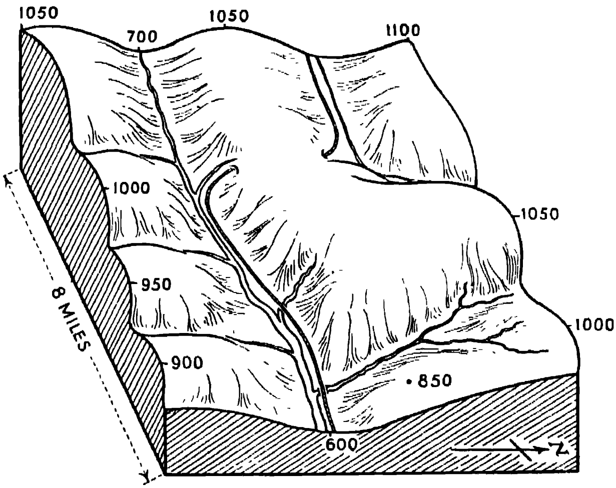


Fig. 19.

a river which receives the drainage of an east to west stream separating these hills from the low plateau occupying the north of the area represented. This river has its headwaters in the plateau and enters the sea through the coastal plain.

(8) Draw a sketch map of the area shown on Fig. 19, using contours at 50 ft intervals.

Other Map Exercises

(1) Study the map given in Fig. 20. It is contoured at vertical intervals of 100 ft, and shows all the surface streams.

(*a*) Calculate the area of the map in square miles.

(*b*) Shade the parts more than 600 ft above sea-level.

(*c*) Print the words "gap", "escarpment", and "dry valley" in their appropriate places on the map.

(*d*) Describe the chief features of the relief of the land.

(*e*) Two railways traverse this area, one from north to south, the other from west to east. Insert them on the map.

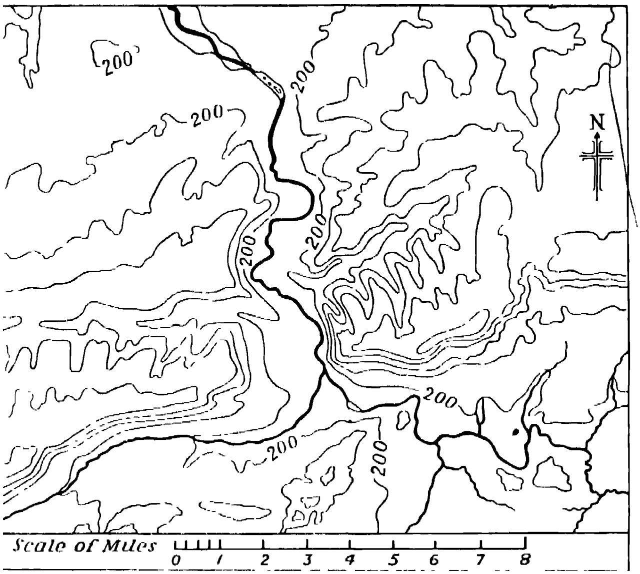


Fig. 20.

(2) Describe the features associated with the river shown on the map (Fig. 20), and compare the character of the valley at different parts of its course.

(3) Compare the streams in the south-east of Fig. 20 with that in the south-west, and make some comparison of the landscape likely to be seen in different parts of the region mapped.

(4) Suggest where, on Fig. 20, village sites are, and are not, likely. Suggest any negative effect of the river on location of village sites, and say what use would be probably made of the land in the main valley.

(5) Study the map (Fig. 21). The contour intervals are 100 ft. The figures near X and Y give the height in feet of the river at these points. Two roads, A to B and C to D, cross the region.

(*a*) Shade the parts over 800 ft.

(*b*) Measure the distance *by river* from X to Y, and find the average fall of the river *expressed in inches per mile.*

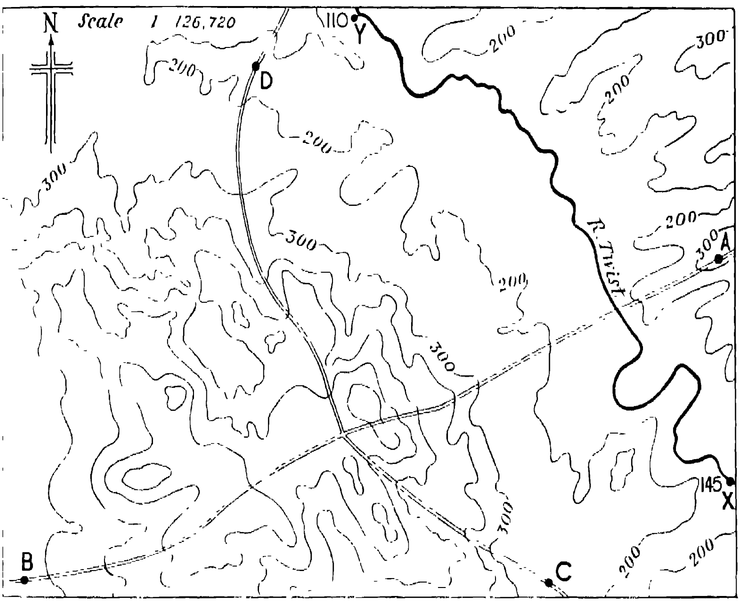


Fig. 21.

(*c*) In what *general* direction is the river flowing?

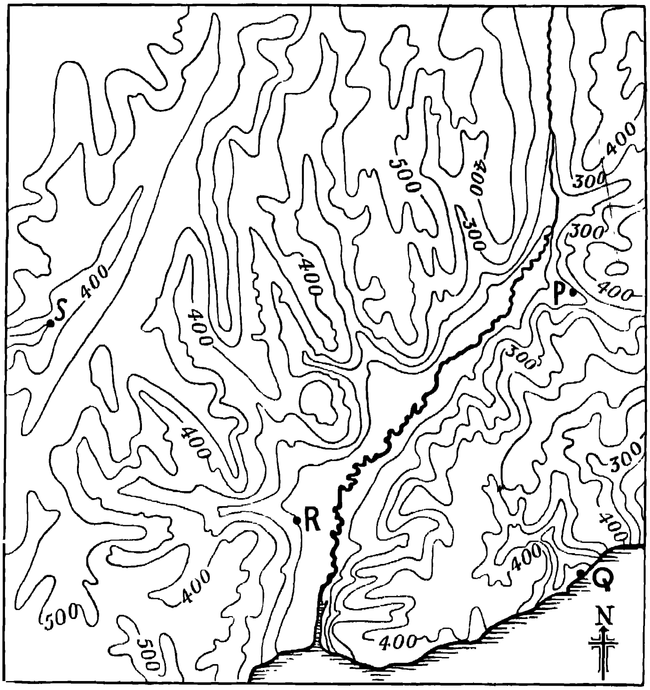
(*d*) Describe *in detail* the course of the road from A to B. How does it differ from that of the road from C to D?

(6) Consider Fig. 21 and:—

(*a*) Describe generally the relief and write notes on the more important physical features.

(*b*) Suggest broad physical divisions.

(7) The map (Fig. 22) shows part of the south coast of England. The contours are drawn from sea-level at 100 ft intervals. Examine the contours carefully and the positions of the points P, Q, R, and S.



Scale 1 : 126,720

Fig. 22.

(*a*) Shade the areas which are 600 ft and over.

(*b*) Draw a profile-section of the country along the line joining S and P.

(*c*) Draw two right-bank tributaries of the main river.

(*d*) Show the most likely track of the railway from Q through R to S, and mark tunnels.

(*e*) Show the watershed in the south-eastern portion of the map (south of P).

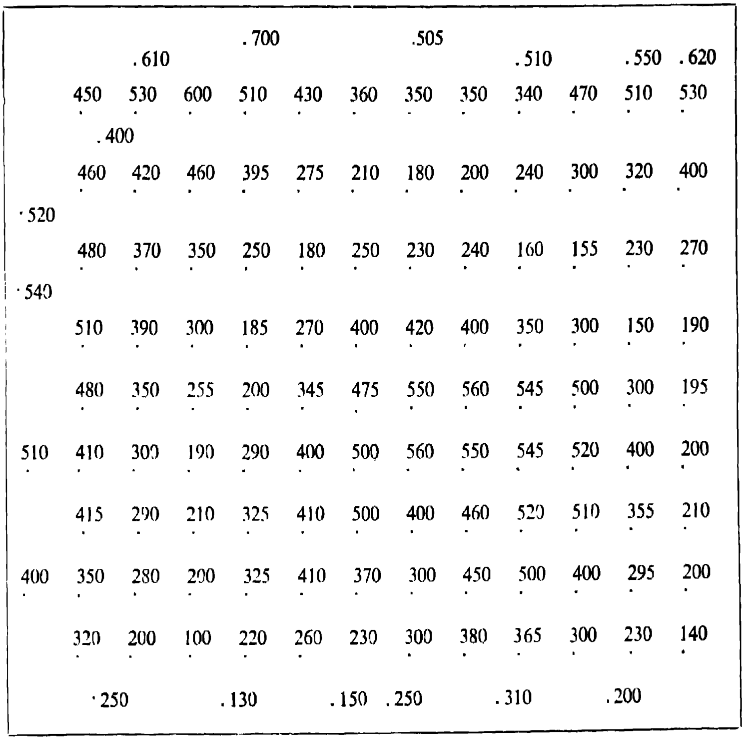


Fig. 23.

(8) The numbers on Fig. 23 represent spot heights.

Insert the contour lines at intervals of 100 ft. (In this type of exercise it is advisable to commence by inserting the highest contour.)

CHAPTER II

THE EARTH AS A PLANET

The World in Space

People in ancient times believed that the earth was the centre of the universe, and that the sun and stars revolved around it. As the study of Astronomy grew, this idea was proved to be wrong, and for a long time it was thought that the sun was the centre of the universe. Modern knowledge, however, has revealed that the sun, while being the centre of the planetary system, is really one of a large number of suns, each with attendant planets, which make up the myriads of stars visible on a clear night. Away out in space, thousands of millions of miles beyond the distant stars of our group (known as the Galactic System, from Galaxy—the Milky

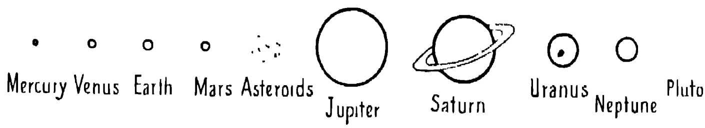


Fig. 24. THE PLANETS.—Mercury is nearest to the Sun and Pluto farthest from the Sun.

Way), are millions of similar groups of stars. These groups are known to astronomers as Nebulae, and each nebula contains in turn millions of suns, most of which have attendant planets or satellites. According to the great astronomer Sir Arthur Eddington, there must be at least 11,000 million million million suns in the universe. What an infinitely small fraction of the whole universe our planetary system must be!

The Planetary System

The Planetary System consists of the sun and nine planets, which with their attendant moons revolve around it. (The moons in turn each revolve around their particular planet, and while the earth only has one moon, Jupiter and Saturn each have nine.) The path of each planet is known as its

orbit, and the orbits of the planets are arranged concentrically with the sun as the centre. Mercury is nearest to the sun, then come in turn Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto (see Fig. 24). Pluto, the smallest, was not discovered until 1930. Although the Planetary System is such a small part of the universe, the distances within it are immense according to our ideas. It would take a swift aeroplane about twenty years to travel from the earth to the sun, and 5,000 years, flying night and day, to cross from one side of Pluto's orbit to the other. Spacious as the earth may seem to us, if we represent it by a tennis ball the sun would occupy a volume equivalent to that of four average classrooms. You may wonder whether life similar to that on the earth exists on the other planets. Venus and Mercury, nearer the sun, are too hot for such life, and the outer planets are too cold. Even Mars is somewhat chilly, and scientists have, as yet, no definite proof that life exists thereon.

The Shape of the Earth

Another misconception of early peoples was the idea that the earth was flat. To-day, we know that the earth is roughly spherical, but instead of being flattened at both ends like an orange, it is rather more like the shape of a pear, being flattened at the North Pole and on those portions corresponding to the South Atlantic, South Pacific, and Indian Oceans (see page 83). The amount of the flattening of the earth is very small. On a 16 in. globe the extent of the flattening would be represented by the thickness of a sheet of paper. The earth is often referred to as a "geoid"—a word which merely means "earth-shaped".

Proofs of the Earth's Shape

There are a number of reasons for the belief that the earth is spherical.

(1) If the earth were flat the sun would rise and set at the same time for peoples in all countries. As we know, the times of sunrise and sunset vary in different parts of the world. This is due to the shape of the earth.

(2) Spheres are the only geometrical shapes that appear to be round from whatever point they are observed. The sun, the moon, and all the stars always appear to be circular in

outline. We can therefore conclude that they are spherical in shape. Why should the earth be the only exception?

(3) The shadow of the earth always has a circular edge. This can be noticed by observation of the earth's shadow on the moon during eclipses. If the earth were a disc, then at times, if it were rotated, its shadow would be elongated or oval.

(4) Viewed from the deck of a ship at sea, the horizon appears to be circular, and if one climbs the rigging the expanse of visible sea greatly increases, but the horizon still remains circular. This is apparent from Fig. 25.

(5) An observer on a cliff watching the approach of a ship sees first the smoke, then the funnels, and lastly the hull. If the earth were flat the whole of the ship would be seen all

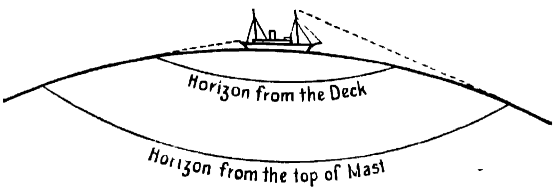


FIG. 25. TO SHOW THAT THE EXPANSE OF VISIBLE SEA INCREASES WITH HEIGHT.

the time, even though at first it was so distant as to be only visible through a telescope.

(6) An experiment was made on the Bedford Level Canal, the surface of the water providing a horizontal level. Three vertical stakes rising to equal heights above the surface of the canal were set in the ground at intervals of three miles (see Fig. 26), and an observer looked through a telescope in such a way that the top of stake A appeared to be level with the top of stake B. It was found that this line of vision AB, instead of passing through the top of stake C, cut it at a point about 6 ft below the top. This could not happen if the surface of the earth were flat. Similar experiments in other localities give the same result.

(7) Finally, we know that we can travel *round* the world in various directions, and come back to the starting point.

The Size of the Earth and the Method of Locating Places on its Surface

For many purposes it is useful to remember that the circumference of the earth is 25,000 miles, and that the diameter is about 8,000 miles. Actually the equatorial diameter is 7,926 miles, and the polar diameter is slightly shorter, viz. 7,900 miles, due to the flattening of the North Pole area.

In order to fix the position of places on the sphere, imaginary lines of reference are used. These are lines of *latitude* and *longitude*. Lines of longitude run north and south, and are all complete circles of the same size passing through both poles. Lines of latitude are at right angles to lines of longitude and run east and west. The line of latitude which is exactly half-way between the poles is called the

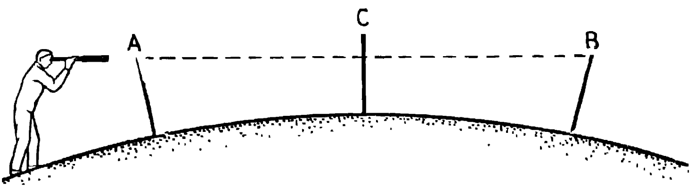


Fig. 26. TO ILLUSTRATE ONE METHOD OF CALCULATING THE CURVATURE OF THE EARTH.

equator (0°), and all the other lines of latitude are parallel to it; thus we speak of the parallels of latitude.

The equator and the lines of longitude are all *Great Circles*. A Great Circle is a circle drawn on the earth in such a way that its centre is also the centre of the earth. In other words, if the earth were divided into two by cutting along the plane of a great circle, then the two portions would be exactly equal, *i.e.* hemispheres. From the foregoing it will be clear that lines of latitude (except the equator) are not great circles. The *shortest line* joining any two points on a sphere is part of the circumference of the great circle passing through those two points. (This can be proved by marking two points on a globe, pulling a piece of string tightly between them, and then continuing the string around the globe.) The shortest flying route between any two places on the earth's surface is therefore along the line of the great circle.

(*a*) LONGITUDE.—Lines of longitude are usually spoken of as meridians, the word "meridian" being derived from a Latin word meaning "midday". All places on the same meridian of longitude have midday at the same time. Study Fig. 27. Let EYXQ be a circle around the earth half-way between the two poles. This circle is called the equator, and as it is a circle it can be divided into 360°. Let C be the centre of the earth, and suppose that the angle YCX contains 20°. Then if NXS is line of longitude 0°, line NYS must be line of longitude 20° W., since it is west of NXS by 20°. Thus it will be seen that 360 lines of longitude can be drawn, all 1° apart. Each line will be a half-circle terminating in the poles. The one which passes through Greenwich we call the Prime Meridian, and is numbered 0°. The half-circle immediately opposite to this one (on the other side of the world) is 180°. The other lines of longitude are numbered east and west of the zero meridian up to 180°. 180° E. and 180° W. are one and the same line of longitude.

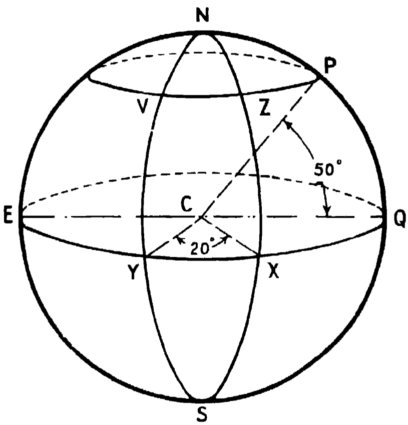


Fig. 27. LATITUDE AND LONGITUDE.

(*b*) LATITUDE.—Lines of latitude are circles drawn round the earth parallel to the equator. Suppose (Fig. 27) PZV be any one such circle. Then if the angle PCQ is 50° this line of latitude is 50° N., and P, on it, is 50° N. of the equator. Since the arc NX is one quarter of a circle that goes right round the earth through the poles, it follows that NX will represent 90° of latitude. Therefore eighty-nine circles of latitude can be drawn parallel to the equator (and to one another) and 1° apart. The ninetieth circle would merely be a point, the North Pole, whose latitude is 90° N. Similarly the latitude of the South Pole is 90° S. The equator is latitude 0°.

By reference to lines of latitude and longitude we can fix exactly the position of all places on the earth's surface. In Fig. 27 the point V is where latitude 50° crosses longitude 20° W., and as this is the only point at which they intersect it follows that 50° N., 20° W. is the position of one place only. Thus the position of point V is fixed.

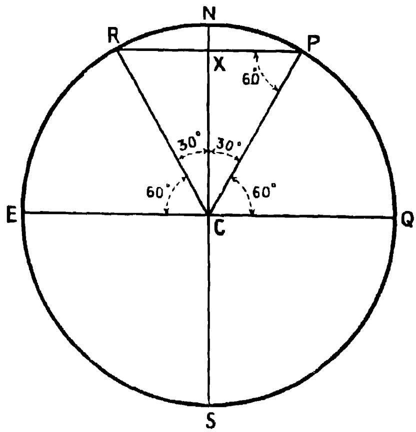


Fig. 28. To Show that Line of Latitude 60° N. is Half the Length of the Equator.

Let P be a point in Lat 60° N.
Then $\angle$ PCQ = 60° and $\angle$ RCE = 60°.
$\therefore$ $\angle$ RCP = 180° − 60° − 60° = 60° also.
$\because$ RP is parallel to EQ
$\angle$ RPC = 60° and $\angle$ PRC = 60°.
$\therefore$ $\triangle$ RPC is equilateral,
$\therefore$ RP = PC = CQ = $\frac{1}{2}$ EQ.

But RP is the diameter of the circle for 60° and EQ is the diameter for the circle of the equator. Since the diameter RP is half EQ it follows that 60° north is half the length of the equator, and that a degree at 60° N. will be half the length of a degree at the equator.

Notice that Z is on longitude 0° and V is on 20° W., therefore V and Z are 20° apart. X and Y are also 20° apart, but VZ is shorter than XY. This is because the lines of longitude approach more closely to one another as they near the poles. Hence the distance between any two meridians at the equator is greater than the distance between the same two meridians in

latitude 50° N. Degrees of longitude decrease in size from the equator to the pole. At 60° N. a degree of longitude is exactly half the length of a degree at the equator (Fig. 28). It is clear from this that we cannot refer to longitude as distance in miles east or west of the Greenwich meridian. It is angular distance, *i.e.* distance measured by angles, which is very different from distance measured in miles, yards, etc.

Lines of latitude, on the other hand, are practically the same distance apart, and since the whole distance round the world is represented by 360° and the actual distance is 25,000 miles, it follows that 1° of latitude is everywhere 25,000 ÷ 360 miles, or about 69·4 miles. There are sixty minutes to the

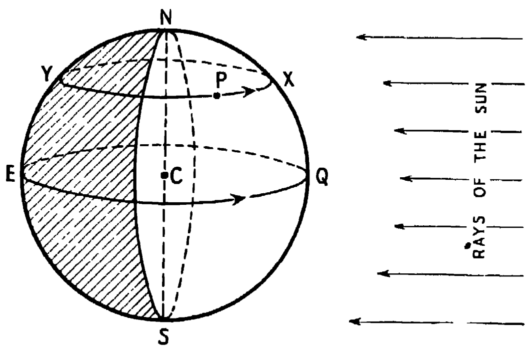


Fig. 29. DAY AND NIGHT.—Showing that all places have days and nights of equal length at the Equinoxes.

degree, and sixty seconds in one minute (these minutes and seconds have nothing to do with those of time). 24° 50′ 20″ N. means that a place is 24 degrees 50 minutes 20 seconds north of the equator.

The Movements of the Earth and their Results

The earth moves in two ways. Firstly it *rotates* on its axis, making one complete rotation in twenty-four hours. This movement causes *day* and *night*. Secondly it *revolves* around the sun, making one complete revolution in approximately 365¼ days. Its path of revolution is known as its orbit. The plane surface in which it moves is called the "Plane of the Ecliptic". The earth's axis is not perpendicular to this plane,

but is inclined at an angle of $66\frac{1}{2}°$ to it. The inclination of the earth in relation to the plane of its orbit is shown on Fig. 30.

Perhaps you will have noticed that globes are always made so that the line joining the North and South Poles is not vertical. The revolution of the earth around the sun and the inclination of the axis together:—

(*a*) Fix the Tropics and the Arctic and Antarctic Circles.

(*b*) Are responsible for the change of the seasons.

(*c*) Cause the *varying* lengths of day and night.

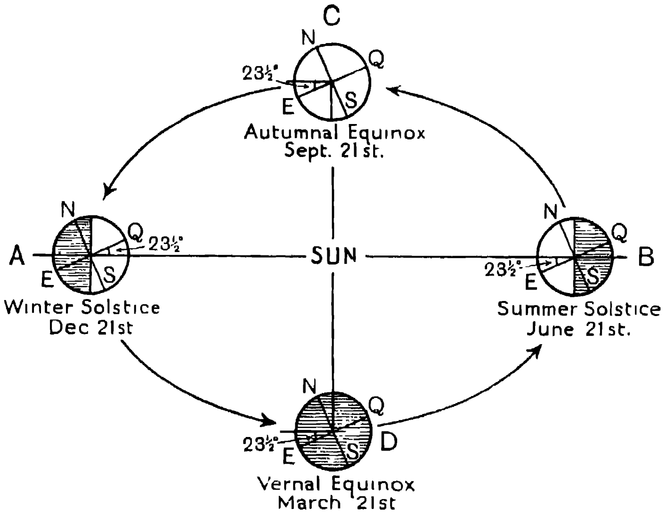


Fig. 30. THE SEASONS.

The Effect of the Earth's Rotation

DAY AND NIGHT.—The diagram (Fig. 29) on page 50 shows how the rotation of the earth causes day and night. The earth rotates on its axis NS, moving in the direction of the arrow from west to east. It is clear that only one-half of the globe can receive the rays of the sun at any given moment, and that the other half must be in darkness. A place P rotates round the circle PXY once in twenty-four hours, and it is obvious from the diagram that its journey will be partly through day-light and partly through darkness.

The Effects of the Earth's Revolution

(*a*) THE TROPICS.—The varying positions of the earth in relation to the sun may be illustrated with the help of Fig. 30.

Place an object to represent the sun at the centre of a table and set the globe in turn at each position shown. Take a plumb line and let it touch the globe in each position. At C and D the string will be a tangent touching the equator, at B it will touch at 23½° north of the equator, at A at 23½° south of it. These, then, are the latitudes where the sun is vertically overhead at noon on the date given.

Thus on September 21st and March 21st the sun is vertically overhead (at noon) at the equator. These days are termed the

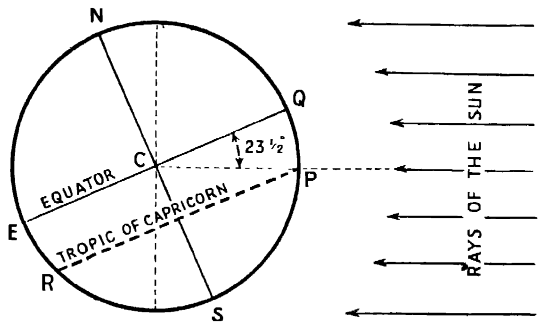


Fig. 31. TO SHOW HOW THE TROPIC OF CAPRICORN IS FIXED.—This diagram illustrates the relation of the earth to the rays of the sun in January. The sun is overhead at P. Every point on PR comes directly under the sun, during one rotation of the earth around its axis NS. ∠ PCQ = 23½° so that PR is the line of latitude 23½° S. and this line is the Tropic of Capricorn.

equinoxes (Latin *Aequus*, equal; *Nox*, night), because, as will be shown later, all parts of the world have equal day and equal night, *i.e.* 12 hours daylight and 12 hours darkness. On December 21st (termed the *winter solstice*) the sun is overhead at 23½° south of the equator, and on June 21st (*summer solstice*) at 23½° north of it. Between the solstices the latitude of the overhead sun changes gradually but is always within these limits.

These latitudes, 23½° N. and 23½° S., which mark the limits of the sun's apparent movement north and south of the equator, are called *tropics*; the Tropic of Cancer is 23½° N., and the Tropic of Capricorn is 23½° S.

Figs. 31 and 32 show how the Tropics are fixed and why their latitude is $23\frac{1}{2}°$ N. or $23\frac{1}{2}°$ S. The sun is never overhead at noon north or south of these two lines, but every place between these two lines has the sun directly overhead at noon twice during the year, once when the sun is moving north to the Tropic of Cancer, and once when it is moving south to the Tropic of Capricorn.

(*b*) THE SEASONS.—The differences of temperature between spring, summer, autumn, and winter are largely the result of the difference in the elevation of the sun at different times of the year, which in turn is caused by the inclination of the

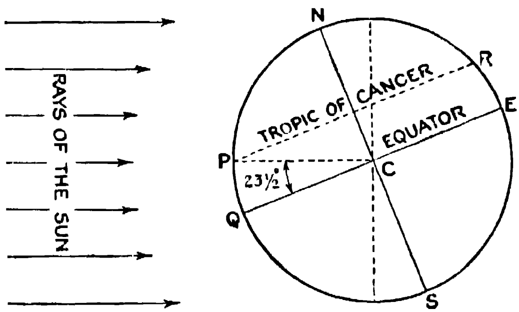


Fig. 32. TO SHOW HOW THE TROPIC OF CANCER IS FIXED.—The sun being overhead at P in June.

earth's axis. It has already been shown that the sun is overhead at the equator in spring (March) and autumn (September), at the Tropic of Capricorn in the northern winter (December), and at the Tropic of Cancer in the northern summer (June). Examine carefully Figs. 33 (*a*), (*b*), (*c*). In the first, which represents conditions in June, the sun is overhead at the Tropic of Cancer. Let us examine the case of a point P in the Northern Hemisphere. The sun's rays, X, strike the earth at an angle Q and heat the shaded area A. In the next figure (March or September) a bundle of the sun's rays, Y, equal in thickness to the bundle X in Fig. 33 (*a*), strike the earth at an angle R and heat the area B. Now while the bundle of rays X has to heat the area A, the equal bundle of rays Y has to heat the area B. Since A is smaller than B, and the heat applied is the same in both cases, it follows that P

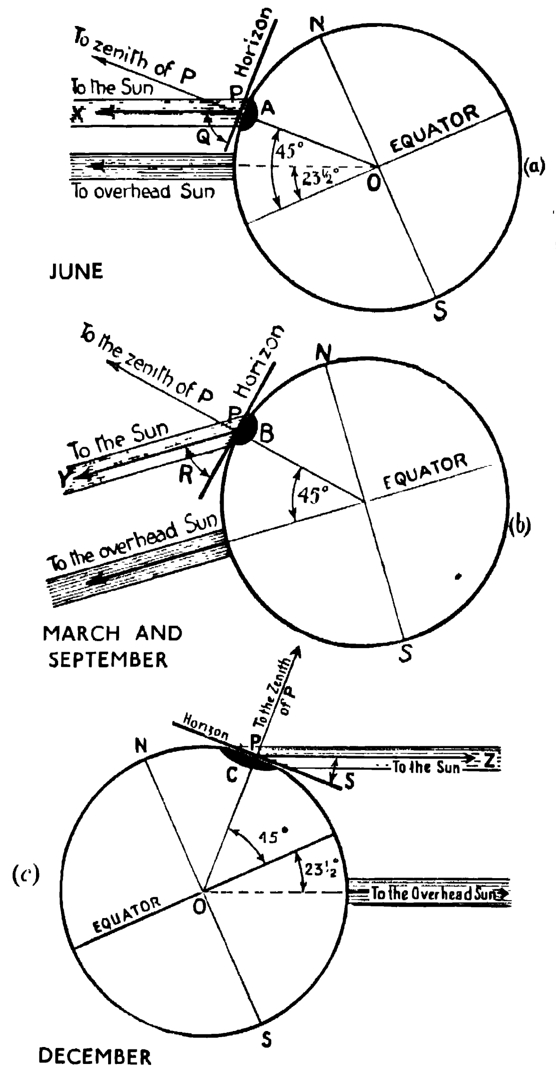


Fig. 33. To show (1) That the angle of elevation of the sun varies at a given place according to the season. (2) Why the temperature of a given place varies from season to season.

will be hotter in the first case (summer), when the sun's rays strike at a greater angle than it will be in the second case (autumn or spring) when the sun's rays strike P at a smaller angle. In December (winter) the bundle of rays Z strike P at an angle S which is smaller than angle R, and area C is still greater than area B, so that P will have lower temperatures in December than at any other time.

If P be taken in the Southern Hemisphere, the reverse conditions will be true, and the seasons are reversed; summer, as the hottest season, being in December, when the sun is

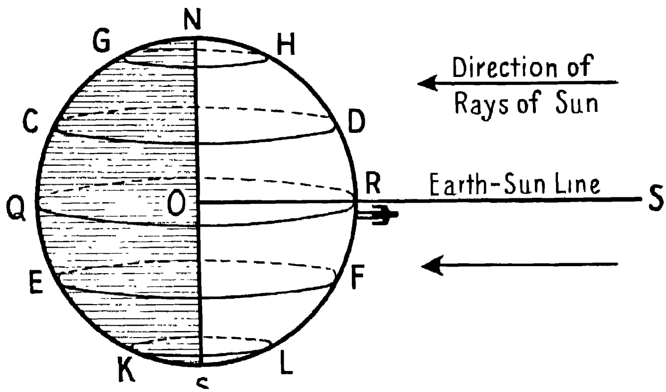


Fig. 34. DAY AND NIGHT.

overhead at the Tropic of Capricorn, and winter, the coldest season, being in June, when the sun is overhead at the Tropic of Cancer.

(*c*) THE VARYING LENGTHS OF DAY AND NIGHT.– The length of day and night varies according to the seasons, and while day and night are due to the earth's rotation, their respective duration is caused by the inclination of the earth's axis. In March and September the sun is vertically overhead (at noon) at the equator. The sun is at such a great distance from the earth (at least 91,000,000 miles) that its rays reach the earth as parallel rays. Let us study Fig. 34. The sun's rays are overhead at the equator, *i.e.* they are overhead for a man standing at R. Since the earth is always rotating on its axis, a point D will rotate through light into darkness and

back into the light. The time taken for one complete rotation of the earth is 24 hours. It will thus be seen that all places (L, F, R, D, H) will rotate through equal lengths of light and darkness, *i.e.* every place on the earth will have twelve hours daylight and twelve hours night.

December (northern winter and southern summer). Fig. 35 represents the conditions during the northern winter. The sun is directly overhead at T, 23½° south of the equator, as is shown by the man standing at T. EQ is the equator, and NS the earth's axis. The shaded portion of the earth is in darkness. It will be seen that any point nearer the North Pole

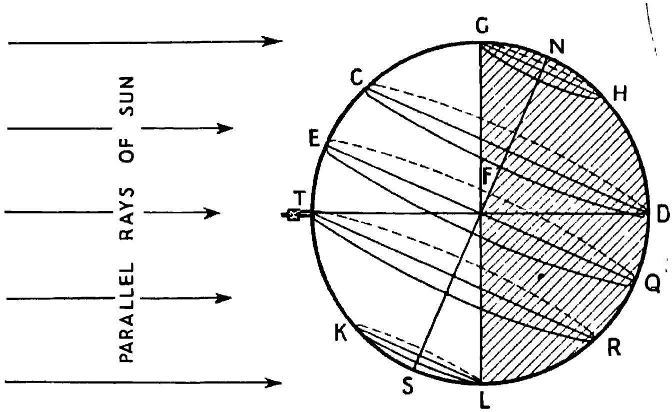


Fig. 35. DECEMBER 21ST. NORTHERN WINTER.—Shaded area in darkness.

than GH will be in continuous darkness as the earth rotates; while any point nearer the South Pole than KL will have continuous daylight. Now examine points C and T. As the earth rotates, C will pass through a short space of light (CF), and a long space of darkness (FD), *i.e.* the days are short and the nights are long in the northern winter. T, on the other hand, will rotate through a longer period of light than darkness, *i.e.* the days of the Southern Hemisphere (having summer) are longer than the nights. Note carefully the point E on the equator which will still have equal day and night.

June (northern summer and southern winter). Examine Fig. 36. The sun is now directly overhead 23½° north of the equator at the Tropic of Cancer, *i.e.* overhead for the man

standing at T. As before, EQ is the equator, NS is the earth's axis, and the shaded portion of the earth is in darkness. On this day any point north of GH will now have continuous daylight. This is why regions in the north of Norway are referred to as the "Lands of the Midnight Sun". Any point south of KL will have continuous darkness. The lines of latitude denoted by GH ($66\frac{1}{2}°$ N.) and KL ($66\frac{1}{2}°$ S.) are the *Arctic* and *Antarctic Circles*, which limit the Polar areas within which all places have at least one day of complete darkness and one day continuous light during the year.

A place D will rotate through less light (DF) than darkness (CF), *i.e.* days are shorter than the nights in the Southern

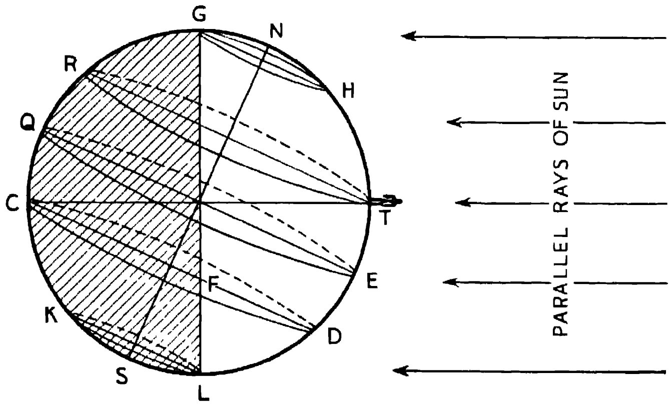


Fig. 36. JUNE 21ST. NORTHERN SUMMER.—Shaded area in darkness.

Hemisphere. In the Northern Hemisphere the days are longer than the nights, for a place T will rotate through more light than darkness. Note again that a point E on the equator will rotate through equal periods of darkness and of light. The equator has twelve hours day and twelve hours night at all seasons of the year. This means that the sun always rises at 6 a.m. and sets at 6 p.m. at any place on the equator.

To find the height of the sun and the length of the day at a given place at a given time.

Suppose you were asked to find the height of the noonday sun and the relative length of day and night at London on June 21st. First find the latitude of London, *i.e.* $51\frac{1}{2}°$ N.

Then draw a circle (Fig. 37) for the earth and on it mark N and S, the north and south poles, EQ, the equator, and C, the centre of the earth. On the circumference mark P, the given place, in such a way that $\angle$ PCQ = $51\frac{1}{2}°$. At P draw (*a*) PZ, the radius PC produced, to represent a line from P to the zenith of the heavens; (*b*) PH, the tangent at P, to represent a line to the horizon. Now ask yourself where the noonday sun will be overhead. In this example it is overhead at the Tropic of Cancer, $23\frac{1}{2}°$ N. Draw CR, so that $\angle$ RCQ is $23\frac{1}{2}°$. Through P draw PS parallel to CR. This line represents the line of the sun's rays striking P, and $\angle$ SPH is the angle of elevation of the sun.

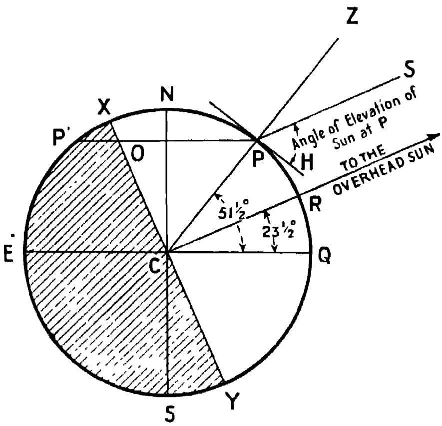


Fig. 37. TO FIND THE ELEVATION OF THE SUN AT A GIVEN PLACE IN JUNE.

$\because$ PS and CR are parallel, and cut by CPZ;

$\therefore$ ZPS = PCR = $51\frac{1}{2}° - 23\frac{1}{2}° = 28°$.

But ZPH is a right angle;

$\therefore$ SPH = $90° - 28° = 62°$—and this is the *required elevation of the sun at noon on June 21st.*

Through C draw XCY perpendicular to CR. Then the hemisphere XEY will be in darkness. The earth rotates around the axis NS; hence P will move along the line POP′. By measuring carefully the lengths of PO, P′O, we can find the relative proportion of day and night. In the example given PO is longer than P′O. Therefore the period of daylight is longer than the period of darkness. The relative lengths of PO and P′O give an approximate idea of the proportion of darkness and daylight during the 24 hours.

The cases of the North and South Poles offer some peculiarities which are best illustrated by means of another diagram (Fig. 38).

N is now the given place. NZ is the zenith line, and NH the horizon line. In March and September the sun is overhead at the equator, so that the sun's rays strike N from the direction NS, which is coincident with NH; hence the sun appears to be *on the horizon*. This position of the sun remains the same for 24 hours, during which time the earth makes one complete revolution. With a little careful thought you will realise that a man at the North Pole will see half the sun all day, instead of the whole sun for half the day. The two poles are the exceptions to the rule that all places in the world have 12 hours day and 12 hours night at the equinoxes.

Twilight and Dawn

You are all familiar with the fact that in winter the lighting-up time for road vehicles is 30 minutes after sunset. In our latitudes there is a period of half-light, called twilight, between sunset and the fall of darkness. There is a similar period called dawn, before sunrise. But at the equator, the periods of twilight and dawn are practically absent, and darkness falls very rapidly after sunset. This is partly because the sun rises almost vertically from below the horizon at the equator (see Fig. 39), and in our latitudes it rises from below the horizon at an oblique angle. During the period that the sun is just below the horizon, we get its refracted

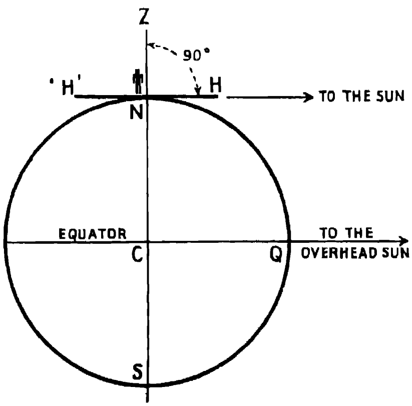


Fig. 38. To Show that the Sun is on the Horizon at the North Pole in March and September.

light, or light diffused by the atmosphere, and this is obviously for a longer period CD than AB in Fig. 39. The same condition and reasoning are applicable to sunset.

Summer Time

It will be seen from Fig. 36 that in summer the length of daylight increases from the equator to the North Pole. On June 21st the equator has 12 hours daylight (6 a.m. to 6 p.m.), in England we have about 17 hours daylight (sunrise 3.30 a.m. to sunset 8.30 p.m.), and the Arctic Circle has 24 hours daylight. "Summer Time" was introduced in a number of European countries so that, by putting the clocks forward one hour,

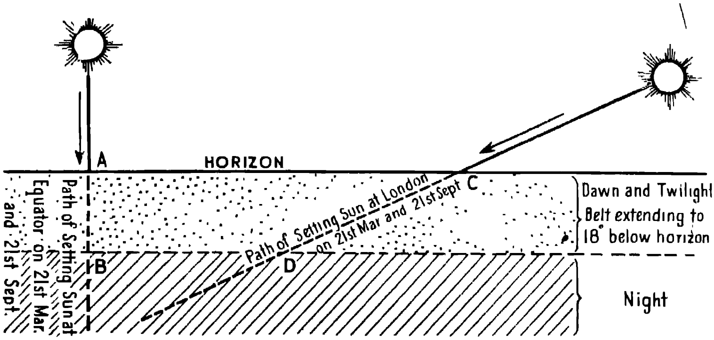


Fig. 39. To Show There is Little Dawn or Twilight at the Equator in Comparison with Higher Latitudes.

sunrise and sunset occur one hour later, thus increasing the daylight period between tea-time and sunset. This scheme extends the possible time for outdoor activities during the summer. Thus, in England, sunset, instead of being at, say, 8.30 p.m. is at 9.30 p.m., and after that there is the twilight period. Note that in Scotland, where the day is naturally longer and sunset at 9.30 p.m. under normal circumstances, Summer Time or Daylight Saving is not so necessary, but that in France, where sunset is earlier (in summer) than in England, it is very effective. Do not imagine that the daylight period is longer, it is the times of our daily routine that are altered, so that we are awake through a longer daylight period and sleep through more of the dark period.

Measurement of Time

The time that it takes for a place to make one complete rotation and come back to its position directly beneath the sun is known as a *Solar Day*. The earth's orbit is not circular but elliptical, and the sun is not centrally placed within the ellipse (see Fig. 40). When the earth is nearest the sun (Perihelion) it is our winter, and when it is farthest from the sun (Aphelion) it is our summer. (Note that our seasons are not determined by distance from the sun, but by the elevation of the sun in the sky and its resultant heating powers; see page 53.) The earth travels more quickly around its orbit when it is in perihelion than it does when it is in aphelion, and therefore solar days

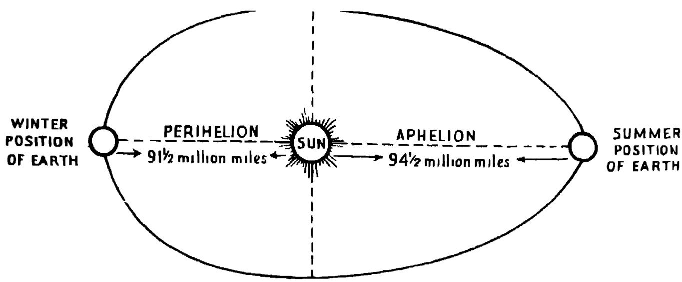


Fig. 40.

vary in length. Because of their variation they are not a convenient basis for the measurement of time. The time by the sun is always given by a sundial. Sundial time is known as Apparent Time, and sundial days vary in length. If the lengths of all the days in the year, as measured by a sundial, were added together and the average found, the result would be a day of uniform length. Such a day is known as a *mean solar day*. The time we use is measured by mean solar days, and clock time is *mean* time, in contrast to sundial time, which is *apparent* time. *Solar* days are sometimes longer and sometimes shorter than *mean* days, and the difference in their length, which may be as much as 15 minutes, is known as the *Equation of Time*. The Equation of Time for each day is given in the Nautical Almanac.

Longitude and Time

In Fig. 41 the sun is shown overhead at A. The time at A is noon or midday. As the earth rotates from west to east the places B and C have already passed beneath the overhead sun, and the time is after midday. But E and D have not yet passed beneath the overhead sun, and so they have not yet experienced noonday, and the time is before noon. One complete rotation of the earth takes 24 hours, *i.e.* the earth turns through 360° in 24 hours,

i.e. 15° in 1 hour, or 1° in 4 minutes.

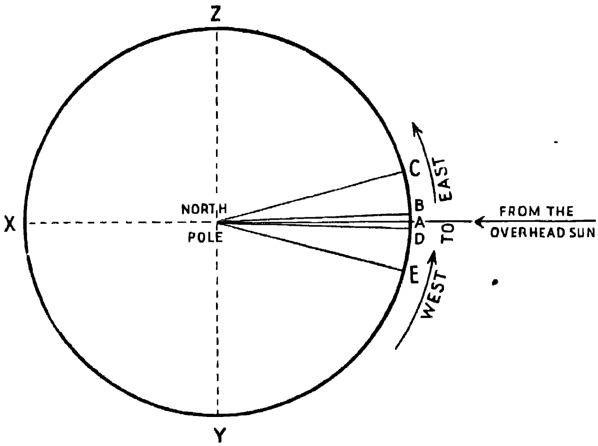


Fig. 41. To Show How the Rotation of the Earth Determines Local Time.

Suppose B is 1° E. of A, then it has taken B 4 minutes to move to its present position from the time when B was situated where A now is. The time at B is 4 minutes past twelve (noon). If C is 15° E. of A, then it is 1 hour since C experienced the overhead sun, *i.e.* the time is 1 p.m. Similarly, if D is 1° W. of A it will be 4 minutes before D reaches the position A, and the time at D is 4 minutes to twelve (noon). If E is 15° W. of A, then the time at E is 11 a.m. The time at X is midnight; the time at Z (90° E.) is 6 p.m.; and the time at Y (90° W.) is 6 a.m.

The sun is overhead for all places on the same line of longitude at the same time. Lines of longitude are "Midday"

lines or *meridians* (Latin *meridies*, midday). As the sun cannot be overhead at two meridians at once, it follows that "Local" time as measured from the noon of the overhead sun must vary from place to place. There will be a difference of 2 minutes between the local time of your town and that of a town about 20 miles east or west of it. Imagine what confusion it would cause if every town and village kept its own

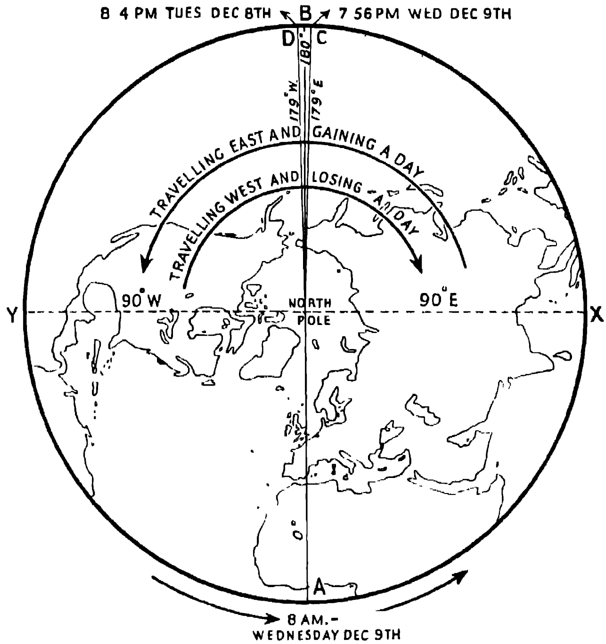


Fig. 42. To Show Why a Day is Gained or Lost When Crossing the Date Line.

time, the clocks and watches had to be constantly altered as one travelled from place to place. To eliminate this confusion the world is divided into Standard Time Belts, each varying by 1 hour, and being roughly 15° in width. In England we take our time (Greenwich Mean Time) from the meridian 0° which passes through Greenwich observatory. This meridian is known as the Prime Meridian, and is used as a basis for the

reckoning of international time. The standard times of various countries in relation to noon at Greenwich are given in *Whitaker's Almanack.*

On long sea voyages clocks are adjusted daily according to the position of the ship. In connection with the variation of time through the world, it is interesting to note that on Christmas afternoon, during the "Round the World" broadcasts, the Australian announcer is speaking in the early hours of Boxing Day morning. The close of play scores of a test match at Sydney are known in England on the morning of the same day, for when play finishes in Sydney at 6 p.m. it is only 8 a.m. in England.

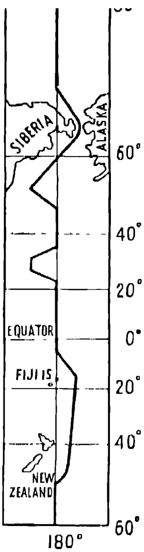


Fig. 43. The Date Line.

The Date Line

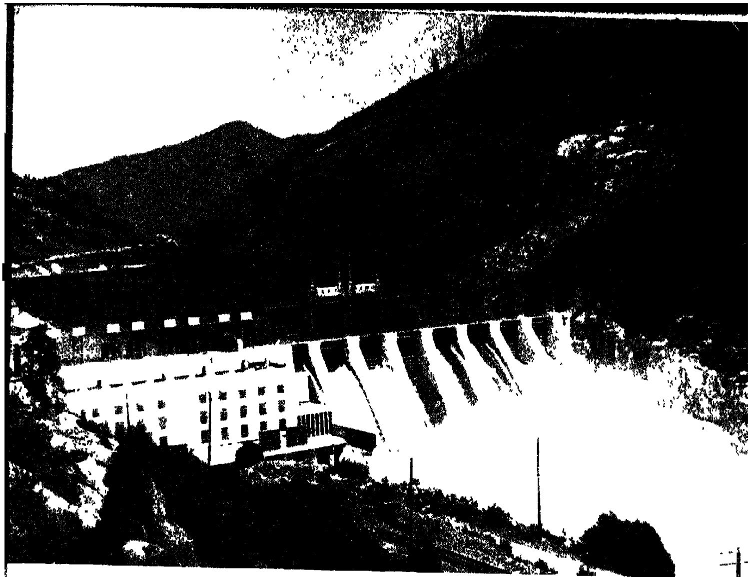
A peculiar position arises at the meridian 180°. This meridian may be reckoned both as 180° E. and 180° W. Study Fig. 42. If the time at A on the Greenwich meridian is 8 a.m. on Wednesday, December 9th, then calculating *eastwards* the time at C (179° E.) will be 7.56 p.m., Wednesday, December 9th; but if the time is calculated *westwards* it will be 8.4 p.m., Tuesday, December 8th, at D (179° W.). Allow 4 minutes more for 1° westwards from D and eastwards from C, and we discover that the time *at B* is both 8 p.m., Wednesday, December 9th, and 8 p.m., Tuesday, December 8th. This confusion of days must be corrected. A ship sailing eastwards through AXBY reaches B on Wednesday, but having passed B it is Tuesday, and the following day is again Wednesday. Ships sailing eastwards therefore gain a day, and the passengers have an "Eight-Day" week the day following Wednesday being called Wednesday. Ships sailing westwards AYBX reach B on Tuesday, and having passed B it is Wednesday. Therefore westward bound ships miss a day from the calendar, and the passengers have a "Six-Day" week, the day following Tuesday being called Thursday. Perhaps a "slang" reference may help you to remember this arrangement, viz. if we travel *west* a day "*goes west*".

PLATE 5

Above. The Takkakaw Falls in the Candian Rockies. Note that the mountains are built up of stratified rocks. Note also the accumulation of broken material (screes) at the foot of the cliffs and the hanging valley (page 122) with its waterfall into the main valley. (*Canadian Pacific Photograph.*)

PLATE 6

The nature of the underlying rocks has an important bearing on both scenery and natural vegetation. *Above.* Chalk country east of Askerswell, Dorset, showing smooth rounded contours and a dry valley. *Below:* An outcrop of Bagshot Sands near Turners Puddle, Dorset. Such land is valueless for agriculture and much of it consists of heath. Heath lands are often used as military training areas. (*Geological Survey, Crown Copyright Reserved.*)



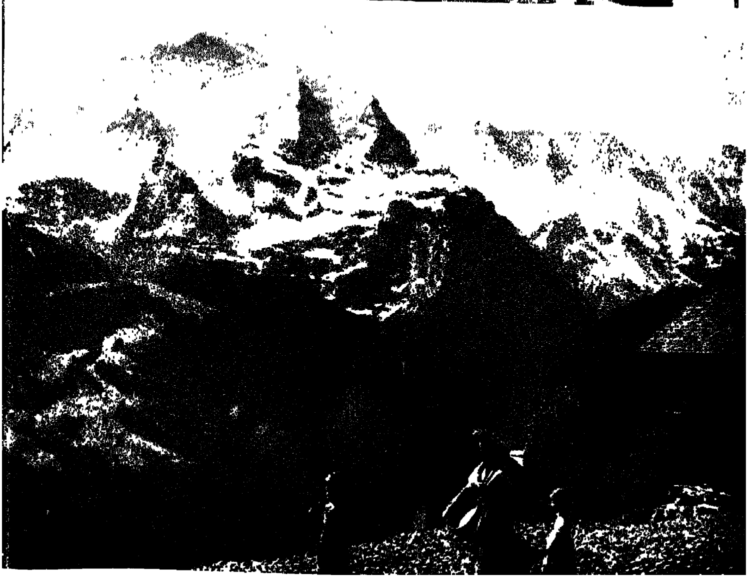


PLATE 7

Above: One of the five dams on the Kootenay River between Nelson and Castelgar (British Columbia) for the production of hydro-electric power. (*High Commissioner for Canada.*)

Below: The Jungfrau, Switzerland.

PLATE 8

Above: A peneplain of old hard rock—part of the Canadian Shield. The camp is an isolated meteorological station. (*Photographic Survey Corporation Ltd, Toronto.*)

Below: Part of the plain of Essex. (*Aerofilms Ltd.*)

Aircraft time-tables are naturally greatly affected. Thus aircraft leaving Auckland, New Zealand, at 3 p.m. on Tuesday arrive at Honolulu, 4,000 miles away, at 1 p.m. *the same day*! But aircraft leaving Honolulu at 3 p.m. on Tuesday arrive at Auckland 9 a.m. on *Thursday*.

If the date line (or the line where the date is changed) followed 180° exactly, it would pass through groups of islands and cause confusion between one island and another. Therefore the date line zig-zags to avoid various groups of islands (Fig. 43).

It curves east of 180° in the Bering Straits between Siberia and Alaska; further south it bends to the west at 180° so as to avoid cutting through the Aleutian Islands. Thus the dates in Siberia and Alaska differ, *i.e.* if it is July 14th in Siberia it is July 13th in Alaska. Longitude 180° cuts through one of the Fiji islands and there would be considerable inconvenience if two parts of the same island had different dates. Therefore in the Southern Hemisphere the date line bends eastward around the Fiji and Tonga Islands. These islands, together with the Kermadec and Chatham Islands, keep the same date as New Zealand.

CHAPTER III

THE BUILDING OF THE CONTINENTS

The Earth's Covering

The earth is composed of an inner core—probably solid throughout and certainly very hot—and an outer crust averaging 40-50 miles in thickness. It is now thought that the composition of the crust is not uniform, but that the continents are composed of less dense substances "floating" on a layer of a denser and heavier material which underlies both the continents and the oceans (see Fig. 44). An interesting feature of the map of the world is the general resemblance of the eastern and western shores of the North and South Atlantic Oceans. It is easy to imagine that if the Americas were pushed eastwards they would fit roughly into the coastline of Europe and Africa—somewhat like fitting two pieces of a jig-saw puzzle together. This is the most obvious example of such parallel coasts of similar shape, but with a little careful study others will be found, viz. (1) among the islands which lie north of Canada, and (2) Madagascar and Eastern Africa. A noted scientist, Wegener, has used these facts, with others, as the basis of a theory of "Continental Drift". Briefly, this means that land masses which were once joined have drifted or "floated" apart.

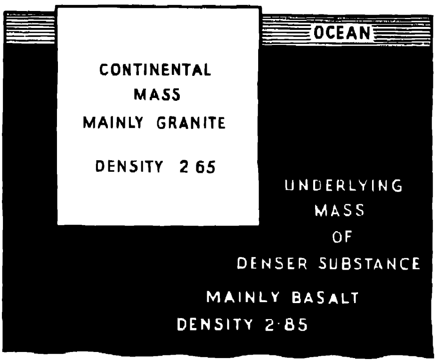


Fig. 44. DIAGRAM TO ILLUSTRATE THE CONCEPTION OF FLOATING CONTINENTS.*

Another theory supposed that all the areas shaded obliquely in Fig. 45 were continuous and formed a continent which

* *Earth Lore* by Prof. S. J. Shand. Thomas Murby & Co.

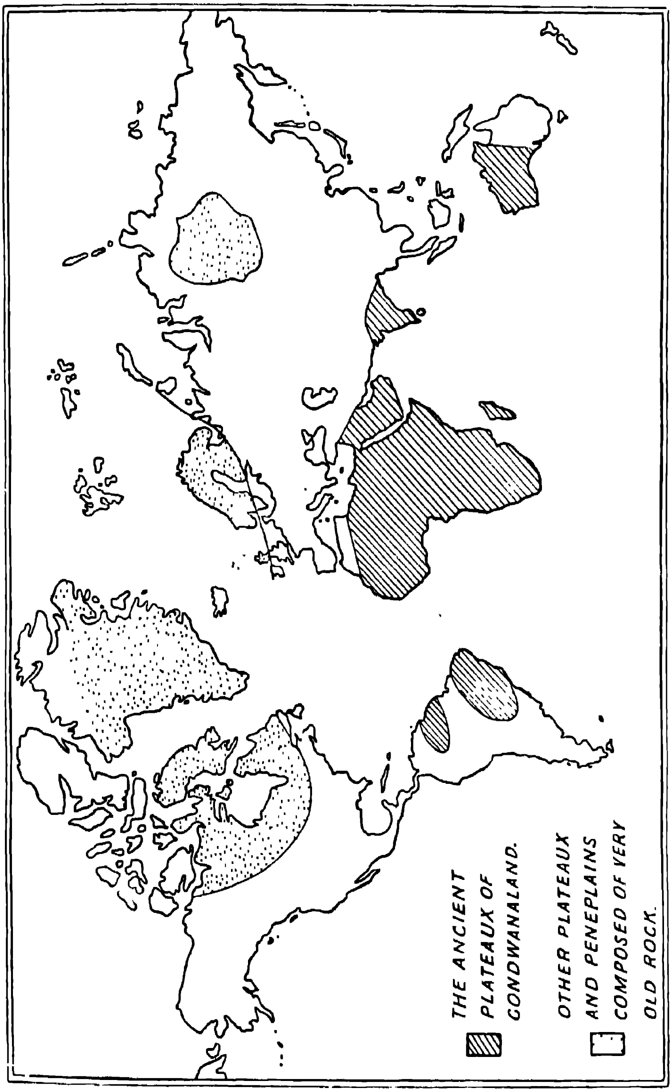

THE ANCIENT PLATEAUX OF GONDWANALAND.
OTHER PLATEAUX AND PENEPLAINS COMPOSED OF VERY OLD ROCK.

Fig. 45.

scientists call Gondwanaland. Some geologists are of the opinion that this continent broke up and portions sank, leaving widely separated areas of similar structure. Wegener, however, suggests that they were once joined but have drifted apart.

Broadly speaking, it will be seen that Wegener assumed that there are two principal groups of rocks forming the earth's crust, the continental masses being composed of relatively light rock, while their foundations and the floors of the oceans are made of rocks which are heavier. Within these two main groups there must be a great variety of rocks but scientists are unable to obtain samples of the rocks beneath the ocean floor. At the surface of the continents, however, geologists have obtained specimens of a wide range of rocks which have been classified in a manner similar to that described in the following pages.

THE PRINCIPAL CLASSES OF ROCKS

The earth's crust is composed of rocks. The term "rocks" includes not only the hard compact masses which may be seen in mountainous areas or in stone quarries, but also the finely disintegrated materials such as sand and soil. The study of rocks is known as Geology, and a knowledge of simple geological terms and of the chief classes of rocks is essential to the understanding of some branches of geography. Mainly according to the mode of their formation and their appearance, rocks may be classified as follows: —

(1) Sedimentary or Stratified Rocks.

(2) Non-Sedimentary or Unstratified Rocks.

- (*a*) Igneous Rocks;
- (*b*) Metamorphic Rocks.

Sedimentary Rocks

A river in flood has a dirty appearance due to the load of soil (gathered further upstream) which the river is carrying. As long as the current is rapid this load of fine soil or *silt* is carried in suspension, but when the speed is checked the silt is deposited. The rapid rate of flow is most effectively slackened when the river enters the sea, and a *layer* of silt is

spread out over the sea floor. Gradually throughout long ages, this silt accumulates, layer by layer, until there is a thick deposit, the weight of which compresses the lower layers into a hard rock. The pressure of the upper layers is not the only cause of the hardening, usually there is also a slow infiltration of some substance which acts as a kind of cement, binding together the grains into a compact mass. With very few exceptions all sedimentary rocks have been formed by the deposition of sediment under water, and they all have a characteristic "layered" formation. The layers are known as strata, and the rocks are said to be *stratified.* The stratification of rocks is often to be clearly seen in a railway cutting or in a quarry. (See plates facing pages 64 and 96.) This process of rock formation has been going on ever since the earth had a solid crust, probably about 500 million years ago.

During these long ages many different kinds of sedimentary rocks have been formed. Provided that the strata have remained undisturbed it will be clear that the bottom layers are older than the layers immediately above them. Geologists use this fact to ascertain the relative ages of rocks and to classify them as "old" or "new". The distribution of land and sea has undergone many and widespread changes, and certain portions of the earth's surface, *e.g.* the Limestone Alps and the Rockies of British Columbia, must once have lain fathoms below the surface of the ocean far from any coastline. Other areas which were once dry land are now submerged, *e.g.* the narrow seas around Great Britain were once dry land. It is largely through the study of the character of the sedimentary rocks that scientists can reveal the story of the changes during past ages.

Sedimentary rocks formed as described above by the *deposition of land-derived materials* are usually various types of sandstones (hardened sands), clays, or shales (hardened muds) (Fig. 46). In addition, sedimentary rocks may be formed by the deposition on the sea floor of the *remains of microscopic sea plants or animals.* These organisms have the power of extracting calcium carbonate from the sea water and using it to build up their "skeletons" or shells. (Oysters, mussels, cockles, etc., also do this to construct their shells.) When the organism dies the skeleton falls slowly to the ocean bottom. The principal rocks formed in this way are

chalk and limestone. In many limestones it is easy to see the remains of small shells, etc., without the aid of a microscope.

Lastly, one group of sedimentary rocks is formed by the depression beneath the sea of *large areas of dense swamp vegetation and forests*. In time layers of sand, silt, etc., are deposited above, and the vegetation is compressed into coal. The effect of the increasing pressure is to alter the plant remains both in composition and in appearance. A compact black mass is formed which is made up chiefly of carbon, and no trace of plant structure is visible to the naked eye. Some people believe that peat represents the first stage in the conversion of vegetation into coal, while lignite, or brown coal, which is found extensively in Europe and North America, represents a more advanced stage. If the pressure applied

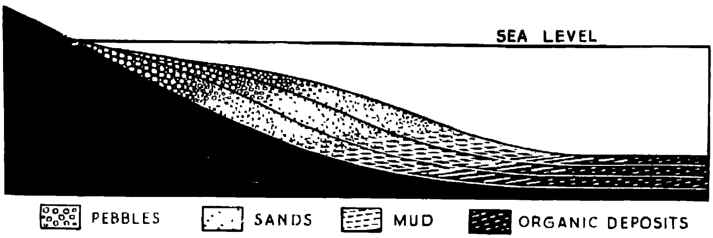


Fig. 46. The Deposition of Land-Derived Material on the Floor of the Sea.

during formation has been greater than in the formation of ordinary coal, a highly mineralised form of coal containing a high percentage of carbon is formed. This is known as *anthracite*, or smokeless coal. Still greater pressure, resulting in the expulsion of everything but the carbon, results in the formation of *graphite*, which is commonly used for the making of "lead" pencils, but which also has a number of industrial uses.

Some rocks, which are classified as sedimentary, may not, according to modern authorities, have been formed under water. Opinions differ as to the origin of the sandstone rocks which can be seen in the Midlands of England, Cheshire, etc. It is possible that they are compressed desert sands—such as the sands of the Sahara. In North China there is a sedimentary rock covering thousands of square miles, called *loess*, which has been deposited by the dust-laden winds blowing

outwards from the deserts of Central Asia. Smaller deposits of loess are found in Europe and other continents.

Non-Sedimentary Rocks, or Unstratified Rocks

As their name suggests these rocks have not been formed by sedimentation, and are not characterised by a layered or stratified appearance. They fall into two groups, viz. (*a*) Igneous rocks; (*b*) Metamorphic rocks.

(*a*) IGNEOUS ROCKS (Latin *Ignis*, fire).—Igneous rocks include all those rocks which have been formed by the cooling of molten rock. The origin of such material is beneath the earth's crust. If, as a result of volcanic action, molten rock reaches the earth's surface, it cools relatively quickly to form volcanic rocks (Fig. 47). Many are glassy in appearance, and

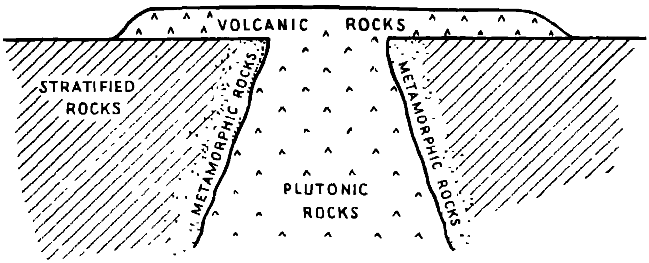


Fig. 47.

others, like basalt, are finely crystalline. Two well-known examples are basalt and andesite. The Giant's Causeway in North Ireland is a familiar example of *basaltic* rock, which splits naturally at angles of 120° to form six-sided columns (see plate facing page 64). Lavas cooling slowly at some depth below the earth's surface (Fig. 47) are known as *plutonic*. The principal example of such rocks is *granite*, distinguishable by its large crystals, which are the result of slow cooling.

(*b*) METAMORPHIC ROCKS (Greek *Metamorphosis*, change). —Metamorphic rocks are those which, as a result of subjection to intense heat or pressure (Fig. 47) have changed from their former state. Originally, they may have been igneous or sedimentary rocks. Owing to heat and pressure, sedimentary rocks often become crystalline in appearance, and are sometimes difficult to distinguish from igneous rocks. By the

processes of metamorphism chalk and limestones are changed to marble; clays and shales to slate; sandstones to quartzite; and granite to gneiss.

The Chief Rocks in the British Isles

The following is a table showing the chief rocks found in the British Isles. Some indication is given of their nature and the localities in which they may be found. The non-sedimentary rocks and the oldest sedimentary rocks are at the bottom of the table and the newest sedimentary rocks at the top. For convenience, the sedimentary rocks are divided into five groups according to their age.

CLASSIFICATION OF THE PRINCIPAL ROCKS, WITH SPECIAL REFERENCE TO THE BRITISH ISLES

GROUP	CHIEF TYPES OF ROCK	WHERE FOUND IN THE BRITISH ISLES
Quaternary. The newest or Fourth Age.	Alluvium, Boulder Clay, Peat.	Parts of Somerset; the Fens, around estuaries and in river lowlands; Dungeness.
Tertiary or Third Age.	London Clay.	Lower Thames basin; Hampshire basin.
Secondary or Second Age.	Chalk, Clay, Jurassic or Oolitic Limestone. New Red Sandstone.	The scarplands of England, South-East of the Tees—Exe line; in the lowlands surrounding the Pennines.
Primary or First Age.	Carboniferous Series (including Coal). Old Red Sandstone. Silurian, Ordovician and Cambrian. (The last three groups contain hard sandstones, limestones, shales, and slates.)	The North and West Highlands of the British Isles; viz Ireland, Cornwall and Devon, Wales, the Pennines and Scotland.
Archaean.	Pre-Cambrian.	North-West of Scotland; the Longmynd in Shropshire.
Igneous and Metamorphic.	Granite, Basalt, Gneiss, etc.	Highlands of Scotland, Cheviots, Western Mountains of Ireland, Lake District, parts of Wales, Dartmoor and the moors of Cornwall.

THE MAJOR LAND FORMS OF THE WORLD

A good physical map of the world shows that, broadly speaking, there are three main types of land to be considered. These are:—

(1) Mountains.
(2) Plateaux.
(3) Plains.

Most of the land surface of the earth can be included under one or other of these headings.

Mountains

Mountains are often classified according to their mode of formation, viz. (*a*) Fold mountains; (*b*) Block mountains; (*c*) Residual mountains; (*d*) Volcanic mountains.

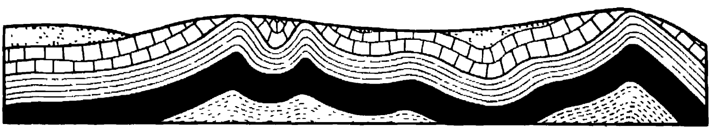


FIG. 48. DIAGRAM TO ILLUSTRATE THE SIMPLE FOLDING OF ROCKS.

(*a*) FOLD MOUNTAINS.—High mountain chains such as the Himalayas, Andes, Alps, and Rockies are known as *new fold mountain* systems. The term "fold" is a reference to the way in which such mountains have been formed. Throughout millions of years slow movements of the earth's crust have caused these mountains to be raised. The movements which have resulted in mountain buildings were not, however, vertical uplifts. They were primarily horizontal movements, the effect of which was to cause the crust of the earth to "wrinkle", in a similar way to which a tablecloth wrinkles if it is pushed along the table. The arched or upraised parts of the folds are known as *anticlines* and the troughs as *synclines*. These folds can vary greatly in size. Compare for example those visible in the photograph of Lulworth (plate facing page 129) with Fig. 48 (*a*), which shows a cross-section across the Southern Pennines. Note that in this latter case much of the anticline has been removed by erosion.

Mountain building is undoubtedly due to some deep-seated cause. For a long period the most simple explanation was that folding was entirely due to the cooling and contraction of the earth, so that the crust, already cold and shrunken, had to wrinkle to fit itself to the still cooling and contracting "core". One of the objections advanced against this theory is that the amount of shrinking necessary to account for the Himalayas, Alps, etc., seems to be greater than the mere contraction of the earth would allow.

While the theory of contraction cannot be completely rejected, serious consideration must be given to the more recent explanations of mountain building. For instance, Wegener suggests that mountain building may be due to the "wrinkles" produced by the drifting of a continental mass, *e.g.*

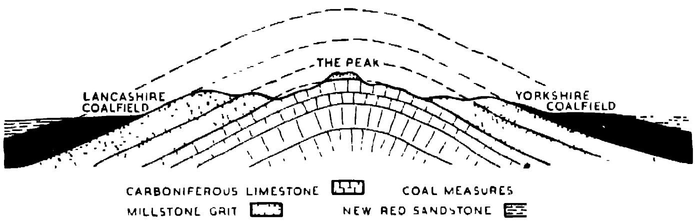


Fig. 48 (*a*). CROSS-SECTION ACROSS THE SOUTHERN PENNINES.- An Anticlinal fold.

that the Alps were formed by the northward drift of the African continent towards the more stable blocks of Central Europe. As the African mass drifted slowly northward the zone between it and the European mass became narrower, and the land was raised into high ridges or folds. The raising of the Alps was accompanied by the formation of the deep trough which contains the Mediterranean Sea. The same hypothesis would account for the building of the Himalayas and the depression of the Indo-Gangetic trough by the northward drift of the Deccan mass.

During the physical history of the earth, mountain building appears to have proceeded more actively at some periods than others. Fold mountains are, therefore, not all of the same age. The newest group of fold mountains include the Himalayas,

Alps, Rockies, and Andes. During an earlier period of folding (the Carboniferous) the Pennines, Appalachians, the Cape Ranges of South Africa, and the Dividing Range of Australia were uplifted. A still earlier period of folding accounted for the original mountains of Scotland and Norway, of which the present mountains are merely the worn down stumps. The older fold mountains, which have been subjected to the forces of denudation (such as the weather, rivers, glaciers, etc.) for long geological periods, are much lower and less rugged than the newer fold mountains.

The term "new fold" is applied to the mountain ranges which have been folded most recently, but they seem very old when their age in actual years is considered because they were uplifted many millions of years before historic time. Mountain building is a very long and slow process; and in the case of certain mountain chains, such as the Andes and the mountains of Japan, is probably still proceeding.

The new fold mountain systems of the world, except in such instances as the simple low folds of the Weald (South-East England), usually consist of high parallel ranges, the average height being well over 10,000 ft. In the Himalayas the highest peak rises to 29,000 ft; in the Andes 23,000 ft; in the Rockies 20,000 ft; in the Alps to 15,000 ft. Vast though these heights appear the wrinkles of the earth's crust are only slight. The highest mountain in the world (Mt Everest) is about 5 miles high, so that on a globe of 16 in. diameter it would protrude only 0·01 in.

Most of the active volcanoes are found in the neighbourhood of fold mountains, where the crust of the earth has been fractured during the process of folding. All around the Pacific Ocean there are many active and extinct volcanoes, as in New Zealand, the East Indies, Japan, and North, Central, and South America. Another belt of active volcanoes is associated with the fold mountains of the West Indies.

The mountains of this type are characterised by ruggedness of relief in contrast to the smooth and rounded contours of mountain areas which have been subjected to weathering agents for long periods of time. This is obvious if pictures of the Alps and the Scottish Highlands are compared.

Mountains are effective climatic barriers, and the climates of regions on either side of a high mountain range are very

different. For example, the coast lands of British Columbia have an equable climate and a heavy rainfall, while the lands to the east of the Rockies have an extreme climate and light rainfall. Again, the climate of the mountainous areas differs from that of the adjacent lowlands.

The great mountain systems of the world are mainly important for their minerals, and, in the temperate zone, for their lumber. In the plateau regions of some mountain systems agriculture has been made possible by irrigation, and above the forests in temperate areas there are valuable alpine pastures. The swift streams of mountains are frequently sources of hydro-electric power, especially in countries which have no coal, such as Switzerland and Norway. (See Plate 7.)

In North America, the Western Cordillera provides gold, copper, lead, and silver, especially in the states of Nevada and Montana. The Andes provide tin and copper (Bolivia), gold and platinum (Colombia), and silver (Peru). The Highlands of East Australia are also important for copper and gold.

The lumbering industry is specially important in British Columbia, Washington, and Oregon (soft woods), the Central American mountainous lands (hard woods), the Himalayan slopes (teak and sal), and the Scandinavian mountains (soft woods).

To provide food for the mining communities in inaccessible mountain areas, agriculture has been developed. There are numerous irrigation schemes in operation in most of the mountain states of the U.S.A., *e.g.* at Salt Lake City in Utah. Similarly, the Andean states, *e.g.* Bolivia, grow small quantities of cereals in the plateau areas.

Mountain pastures have been utilised most extensively for cattle rearing in Switzerland and Scandinavia.

The vast central plateau of Asia is, owing to difficulty of access and climatic extremes, so isolated from other regions that very little development of any kind, on modern lines, has taken place.

High mountain ranges are also barriers to communication, and so tend to separate peoples. Traffic across mountains is limited to the passes which are often so high as to be

snowbound in winter. Such ranges as the Alps, Andes, etc., can only be crossed with great difficulty or by expensive tunnelling.

(*b*) BLOCK MOUNTAINS.—It sometimes happens that movement of the earth's crust occurs along cracks or faults. Where such movement leaves a block of higher land standing between two areas of lower land, the highland is known as a "Block Mountain" or *horst*. The Vosges and Black Forest Moun-

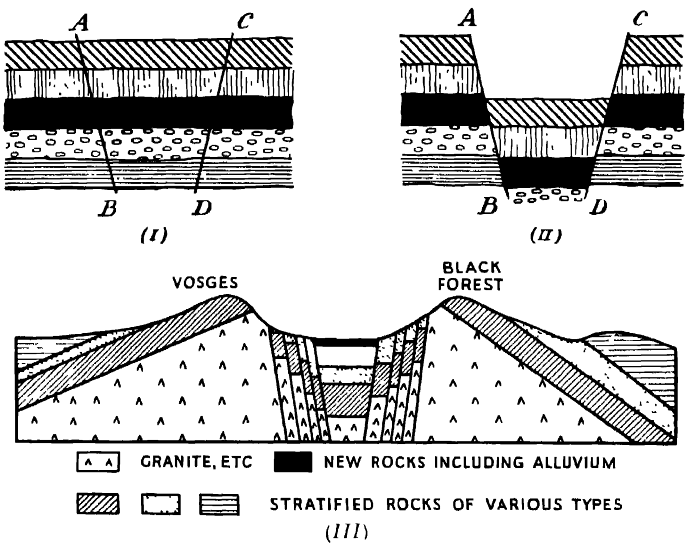


Fig. 49. (I) AND (II). A SIMPLE CONCEPTION OF A RIFT VALLEY (III) SECTION ACROSS THE RHINE RIFT VALLEY.

tains are examples of such formations (Fig. 49). These mountains are usually very steep-sided, and often the summit levels are roughly the same.

(*c*) RESIDUAL MOUNTAINS.—When an area of highland remains standing above the general level after rivers and other natural agents have lowered the surface of the surrounding area, the name *residual* mountain is used. Sometimes such highlands are called "mountains of denudation". This term can usually be applied to the mountain ridges associated with "dissected plateaux". Included in this class are the mountain

ridges of the Highlands of Scotland, the Sierras of Central Spain, and the *Mesas* and *Buttes* of the western plateau lands of the United States. Note for example the uniformity in height of the ridges in the background of Helvellyn (plate facing page 97).

(*d*) VOLCANOES.—Mountains may be formed by volcanic material piled up round a crater (see page 134).

Plateaux

A *plateau* or tableland generally denotes a large stretch of highland which is practically the same height above sea-level, and which descends on all sides to lower ground. Some plateaux, however, such as those of Tibet and Bolivia, that are fringed by high mountain ranges which tower above the plateau level, are known as *intermont plateaux*. Sometimes they are so completely enclosed as to have no outlet to the sea. A plateau might be regarded as an elevated plain, but there is often a great difference between the surface of a plain and that of a plateau. As a plateau is high, rivers are swift and carve deep, narrow valleys instead of the broad, open valleys of the slower rivers of the plains. Such plateau areas as Wales, and the Highlands of Scotland, are broken by deep, narrow valleys, and are termed *dissected plateaux*. On reaching the top of such an area one has a long view of a series of flat-topped mountain ridges. These ridges are all of approximately the same height, and if one imagines the clouds descending until they touched one ridge, then almost every other ridge would be similarly cloud-capped. Other good examples of plateaux are Tibet in Asia, the Ecuador and Bolivian plateaux in South America, and nearly the whole of the continent of Africa. The Deccan of India is a plateau that has been tilted so that the western edge is much higher than the eastern edge, and all the main rivers drain eastwards.

If you study Salisbury Plain in your atlas you will see that it is higher than the surrounding country. It is, in reality, a low plateau, and not a plain, but the term "plain" has apparently been applied because of the level nature of its surface.

In many instances plateaux are formed by the denudation or wearing down of higher mountainous areas. Ultimately such areas may become so low that they are nearly plains, i.e. *peneplains*, such as the land around Hudson Bay.

Millions of years ago lava was forced up through cracks in the earth's crust, and spread out over the land in great sheets which have since hardened to form plateaux of basalt. Two well-known examples of such plateaux are in Antrim (N.E. Ireland), and on the Deccan of India to the east of Bombay.

Many of the most extensive areas of plateaux in the world are composed of very hard old rock. The Guiana Highlands, most of Africa, Arabia, the Deccan of India, and the West Australian plateaux are all composed of rocks of similar age. These are shown on Fig. 45.

The ancient plateau lands are principally valuable for their minerals, such as the gold of Western Australia; the iron and manganese of the Brazilian Highlands; the gold, copper, and diamonds of the African plateau; and the gold of the Lena plateau in Siberia.

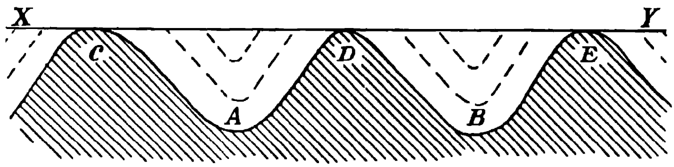


Fig. 50. Shaded area represents land. Dotted lines illustrate the growth of the valleys. This shows how a plateau is "dissected".

Where plateaux are found in tropical areas they are important because, being cooler than the neighbouring low-lands, they offer greater possibilities for successful European settlement and development. The highlands of Brazil, Kenya, and Tanganyika are illustrations of this.

Much of the tropical plateau area is covered by savana grasslands. For the most part, these areas are not yet developed, but offer possibilities for the production of a large variety of both animal and vegetable products, when communications have been developed and further settlement has taken place.

Plains

A *plain* is an expanse of low and nearly level land. Some plains, such as the Fens of England, large parts of Holland, and extensive areas of Russia, are almost perfectly flat; but generally an extensive plain consists of wide, gently sloping

valleys separated by low hills. Such a plain is termed "rolling" or "undulating". Many plains look extremely flat when viewed from the top of the neighbouring hills, but on descending one finds numerous instances of steep gradients, these being the valley slopes of the streams which cross the plain.

Plains are not all of the same type. Firstly, some may have been formed by the wearing down of lands that were once much higher. Such areas are more correctly called "peneplains". Examples are Finland, a lowland area of very old rock, and the Hudson Bay lowlands. (See plate facing page 65.)

Secondly, where layers of rock have not been folded but remain almost horizontal, extensive plains also occur. The Central Plains of the United States and the great plains of European Russia are in this group.

Thirdly, plains may have been formed by the gradual accumulation of silt brought down by rivers. These are usually called *alluvial plains*. Good examples are the plain of North China, the Indo-Gangetic plain, the plains of Iraq, and much of the Amazon lowland. Some plains are the beds of old lakes. Rivers entering a lake deposit silt which is spread by the movement of the water over the lake floor. Such plains, though not large in size, are usually very fertile. Much of the great wheat land of Southern Manitoba is the bed of an old lake—Lake Agassiz. The fertile plains of Hungary are of similar origin.

Finally, some plains are formed by the uplift of part of the sea floor bordering a continent. The coastal plains of the United States from Chesapeake Bay to Florida were formed in this way.

The plains of the world tend to be areas of most advanced development and densest settlement. They are easier to cultivate than highland areas as the soil is usually deeper and more fertile. Hence the great plains, except where covered with large tracts of uncleared forest or occasional deposits of infertile soil, are important agricultural lands. Some plains, such as portions of Central Asia or of the Murray-Darling Basin, are too dry for successful agriculture. Unless irrigation is a practical possibility such plains are occupied by pastoral farmers engaged in rearing animals, and even the pastoral farmers sometimes have to bore wells for water, as in

Hungary and in Australia. Where coal is found in or near plains, densely populated industrial centres usually develop, as in the North-Central United States. Movement is easy in all directions over lowlands, and rivers are generally slow and easily navigable, so that they are used as commercial highways. This is well illustrated by the United States where the Mississippi and its tributaries provided the main lines of communication before the period when railways were developed.

Distribution of Land and Water

Land and water are not uniformly distributed over the earth. There is more than twice as much water (71 per cent.) as land (29 per cent.), but in the Northern Hemisphere the areas of land and water are nearly equal, while in the Southern Hemisphere there is nearly fifteen times as much water as land.

A careful study of a globe reveals a number of outstanding points concerning the distribution of land and water.

(1) In nearly every instance if there is land in one part of the globe then there is water opposite to it on the other side of the earth. Even the North Polar *Ocean* is opposite to the Antarctic *land mass*. (See Fig. 51.)

(2) The greatest land masses form an almost complete girdle around the Northern Hemisphere in the temperate latitudes.

(3) The land masses are narrowest in the Southern Hemisphere.

(4) The Antarctic land mass has three protruding areas, one extending towards South America, a second towards South Africa, and a third towards Australia.

Some scientists have attemped to account for this arrangement of land and water by the "Tetrahedral Theory", but this explanation is not accepted by all. It is based on the assumption that as a sphere collapses or contracts, it tends to become tetrahedral in shape. (A tetrahedron is a pyramid with four triangular faces, *i.e.* a three-sided pyramid on a triangular base.) If this assumption is correct then the distribution of land and water is explained by the diagram (Fig. 52), the continents corresponding to the edges of the tetrahedron and the oceans to the faces.

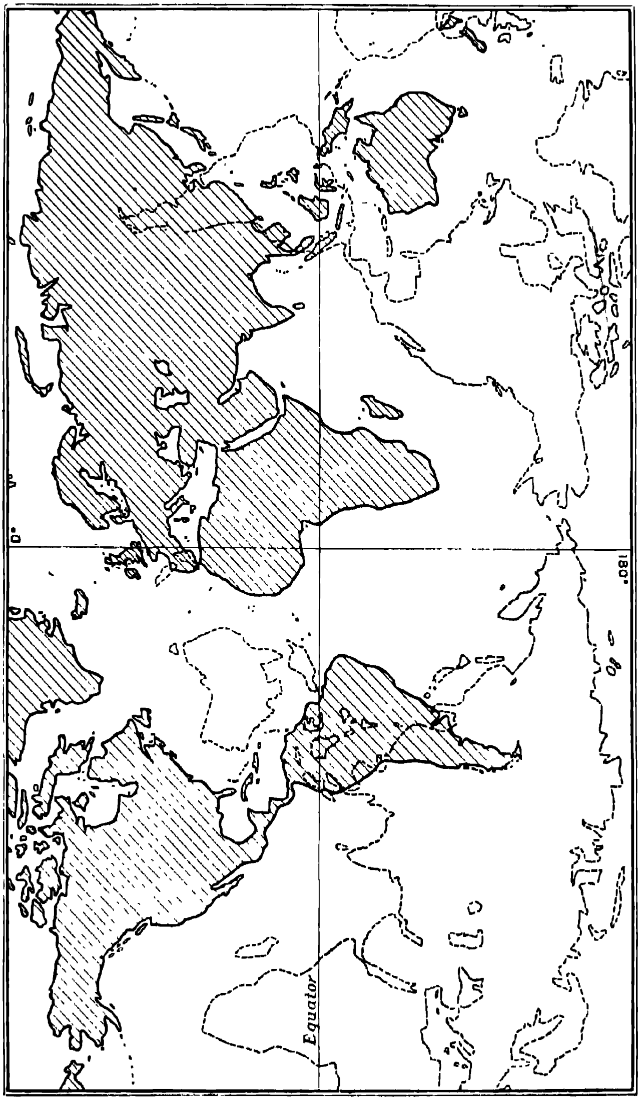


Fig. 51. To Show the Antipodal Distribution of Land and Water.

The following important facts may be said to arise from this distribution of land and water:—

(1) The development of a Northern Hemisphere "girdle" of communications: viz. North Atlantic sea route, North American transcontinental railways, North Pacific routes, and the Trans-Siberian railway.

(2) East to west routes are important in the Northern Hemisphere, in contrast to the importance of north to south routes in the Southern Hemisphere. There is no important east-west route linking South America, South Africa, and Australia.

(3) The southern continents, especially Australia, are more isolated than the northern land masses.

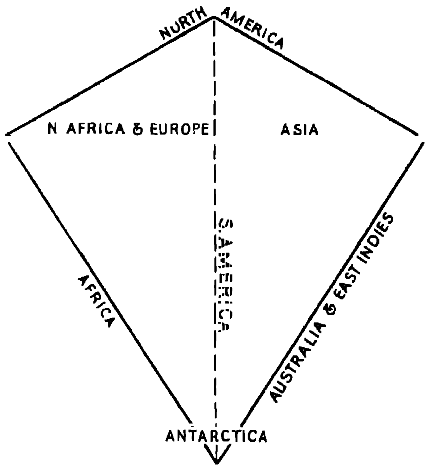


Fig. 52. Diagram to Illustrate the Tetrahedral Theory of the Distribution of Land and Water.

(4) The development of world airways is easier in the Northern Hemisphere than in the Southern Hemisphere.

(5) The interior of continents of the Northern Hemisphere have great variations in summer and winter temperatures, while the climates of the Southern Hemisphere are more equable.

(6) Because the southern continents do not extend beyond 55° S., there is a complete "circle" of ocean between the southern continents and Antarctica.

(7) The southern land masses are relatively narrow in temperate latitudes, so that there is less land in the Southern Hemisphere suitable for white settlement than in the Northern Hemisphere.

CHAPTER IV

THE OCEANS

The Ocean Floor

The sea fills all the hollows of the earth's surface that lie below "sea-level" with the exception of a few landlocked depressions, such as the land surrounding the Caspian Sea, the polders of Holland, and the valley of the River Jordan. Whereas the average height of the land above sea-level is 2,750 ft, the average depth of the oceans is 12,300 ft. The greatest depth of the ocean at present known is 35,600 ft (the Mariana Trench south-west of the island of Guam). On a globe of 16 in. diameter this deep abyss would only be shown by a scratch $\frac{1}{100}$ in. deep, showing that the mountain heights and ocean deeps make very little difference to the spherical shape of the earth, in fact no more than the irregularities on the skin of an orange.

The ocean floor is often referred to as being composed of four parts:—

(*a*) *The continental shelf*, a shallow area surrounding the land masses and never more than 600 ft (100 fathoms) deep. The boundary of the continental shelf is known as the continental edge.

(*b*) *The continental slopes*, the steep slopes descending from the continental edge to the deep sea plains.

(*c*) *The deep sea plains*, a monotonous undulating area usually more than two miles below sea-level, and comprising the greater portion of the ocean floor. In some places the oceanic plain plunges to great depths known as the ocean deeps.

(*d*) *The ocean deeps*, which are usually long, narrow, trough-like depressions.

These four divisions are shown on the section of the Atlantic Ocean (Fig. 53).

The Atlantic Ocean

In shape, the Atlantic Ocean is somewhat like a letter S. The coastlines of the Americas, and Europe-Africa being

approximately parallel. In the north, where extensive plains reach down to the sea, there are wide areas of continental shelf on both the eastern and western sides; viz. (*a*) round the British Isles; (*b*) around Newfoundland and North-Eastern U.S.A. In contrast, the continental shelf in the South Atlantic is much narrower, especially where the plateaux of Africa and Brazil drop steeply to the coast.

Running southwards in the middle of the Atlantic, half-way between the two continental masses and roughly parallel to their coasts is a submarine ridge. This ridge, known as the Dolphin ridge in the North Atlantic and the Challenger ridge in the South Atlantic, occasionally rises above sea-level. Where this occurs are islands such as the Azores, St Paul's Rocks, Ascension, and Tristan da Cunha. Such islands as these are known as *oceanic islands* because they rise from the

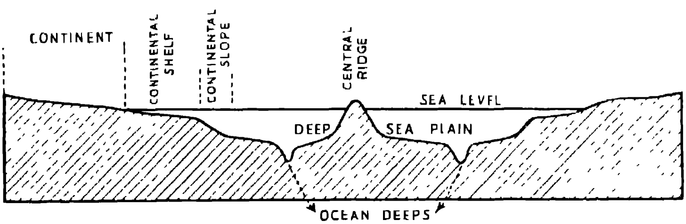


Fig. 53. Diagrammatic Section of the Atlantic Ocean.

depths of the ocean; in contrast, islands like Newfoundland and the British Isles which rise only from the shallow floor of the continental shelf are known as *continental islands*.

On each side of the Central Atlantic ridge are the great deeps, but the deepest Atlantic sounding yet taken is that of the Nares deep (27,972 ft) just north of Porto Rico.

The Pacific Ocean

In contrast to the Atlantic Ocean, the Pacific Basin is almost everywhere surrounded by high mountain chains (*e.g.* Andes) or volcanic islands (Japan). The results of this are twofold:—

(1) There is relatively little continental shelf.

(2) The sea floor drops very steeply from the continental margins so that the great ocean deeps are very near to the eastern and western margins of the ocean; *e.g.* the Tuscarora

deep (off East Japan), the Mindanao deep (off the Philippines), and the Russell deep near to the coasts of Chile (Fig. 54).

A well-marked line of deeps extends from Japan southwards, keeping just to the east of the Ladrone, Marshall, Tonga, and Kermadec Islands. These islands seem to form the outer edge of a platform, 2,000-4,000 ft deep, which extends eastwards from Asia and Australia. A similar platform stretches westwards from South and Central America. Between these two platforms the ocean bed sinks to the deep sea plain. From the Pacific submarine platforms rise plateau-like areas which are topped by volcanic and coral islands (see page 144), *e.g.* Hawaii.

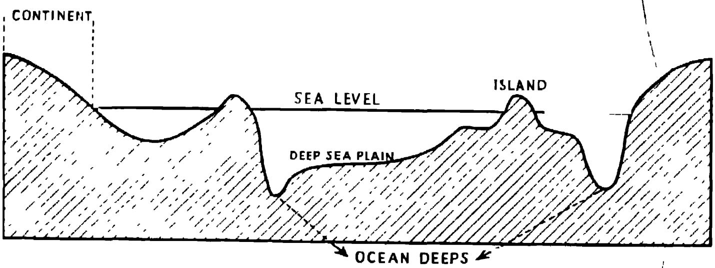


Fig. 54. Diagrammatic Section of the Pacific Ocean.

The Covering of the Ocean Floor

The floor of the ocean is covered with muds, oozes, and clays. The muds and clays are derived from land and are often termed *Terrigenous* (land-derived) deposits, but the oozes are formed by the deposition of the skeletons of minute sea organisms, and are termed *Pelagic* (ocean-derived) deposits.

(1) Muds.—These include all gravels, sands and silt carried out to sea by rivers, and material broken by waves from the sea coasts. It is usually dull blue in colour (blue mud), and extends over all areas of shallow water surrounding the land masses. Where there are very strong river currents (*e.g.* the mouth of the Amazon) blue mud may be found 400-500 miles from land, but its usual limit is 200-300 miles out to sea. On the "continental slopes" these muds are finer in texture and are often green or red, varying in colour according to their chemical constituents.

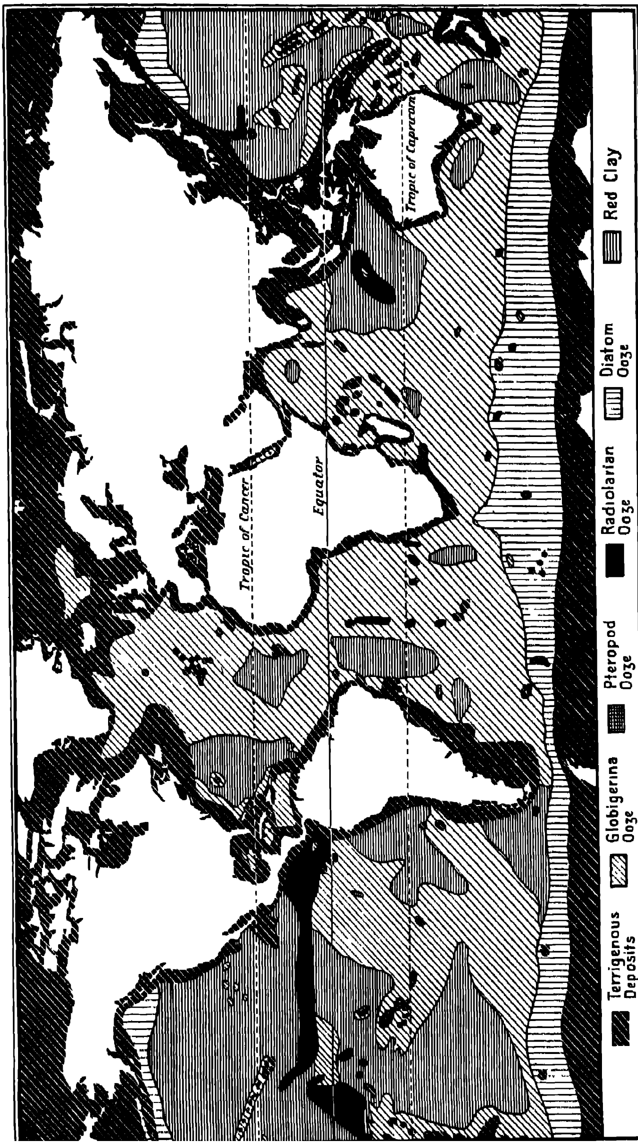


Fig. 55. OCEANIC DEPOSITS.
(*Based on the Oxford Advanced Atlas by Bartholomew.*)

(2) OOZES.—Living in the ocean waters are countless millions of microscopic organisms. For the most part these are in suspension. As these organisms die they descend to the ocean floor and one may imagine a constant "rain" of them on the bottom of the ocean, resulting after very long periods of time in the formation of deposits composed of the tests or skeletons of these organisms. It will be realised that these deposits grow extremely slowly. These accumulations are known as oozes, and are found on the ocean floor far away from the continents. The general colour is light grey, and when dry an ooze is rather like flour in texture. There are four principal types of ooze:—

(*a*) Globigerina }
(*b*) Pteropod } composed of Calcium Carbonate.

(*c*) Diatom }
(*d*) Radiolarian } composed of Silica.

Globigerina ooze is very widespread. It covers most of the floor of the Atlantic Ocean and much of the Indian and South Pacific Oceans.

Pteropods live only in warm oceans, and as they dissolve before they reach the deep sea plains, pteropod ooze only occurs in shallower waters (less than 1,000 ft deep). Thus this ooze is found in patches on the Atlantic ridge and on the submarine elevations of the Pacific and usually within the tropics.

Diatoms flourish in the cooler oceans, and diatom ooze is found in a wide belt encircling Antarctica.

Radiolarians, in contrast to Diatoms, and like Pteropods, live in the warmer seas. As the siliceous skeletons do not dissolve easily, radiolarian ooze is found at great depths, in the inter-tropical areas of the Indian and Central Pacific Oceans.

It is obvious that the remains of sea organisms will also accumulate on the sea floor near to the continents. Here, however, it will be mixed with such a large amount of land-derived material that the percentage of "ooze" is negligible.

(3) RED CLAY.—This is a stiff brownish-red clay found over very large areas in the Pacific Ocean, and in the great deeps

of the Atlantic and Indian Oceans. The chalky and siliceous remains of sea organisms completely dissolve before they reach these great depths, hence oozes are absent. Red clay is thought to be the accumulation of dust particles which have been blown out to sea after volcanic eruptions, and which, being insoluble, have gradually sunk to the ocean floor. Red clay therefore accumulates very slowly. Such particles would also reach the sea floor in the shallow areas, but there the other oozes predominate.

The Salinity of the Ocean

The average salinity of the ocean is 3·5 lb. of salt to 100 lb. of water, or 35 lb. to 1,000 lb. of water (written $35^{\circ}/_{\circ\circ}$). These salts include sodium chloride (common salt) of which there is 27 lb. to 1,000 lb. of sea water, and also compounds of magnesium, potassium, and calcium. The rain water flowing over the land surface or sinking into the soil and into the crevices and pores of the rock, perhaps eventually reappearing as a spring, carries away certain minerals in solution. All river water contains dissolved minerals which are eventually carried to the sea. It might reasonably be thought that the composition of sea water should be similar to that of river water, but this is not so. Calcium carbonate is not, however, the principal salt contained in sea water, because sea organisms are constantly absorbing it to build their shells and skeletons.

The salinity of sea water is not uniform, and it depends mainly on two factors, viz.:—

(1) The amount of fresh water added by rivers and rainfall.

(2) The rate of evaporation.

Excluding certain partially-enclosed seas which will be discussed later, the salinity of the oceans varies in marked east to west-trending belts. Since warm water will dissolve more of a given substance than cold water it would be expected that the areas of greatest salinity would be near the equator. This is not so.

(*a*) In the equatorial areas, the rainfall is heavy and occurs almost daily, and the relative humidity of the atmosphere is high so that there is little evaporation. In addition there are rivers of large volume (*e.g.* Congo and Amazon) which constantly supply fresh water. As a result the salinity is not high

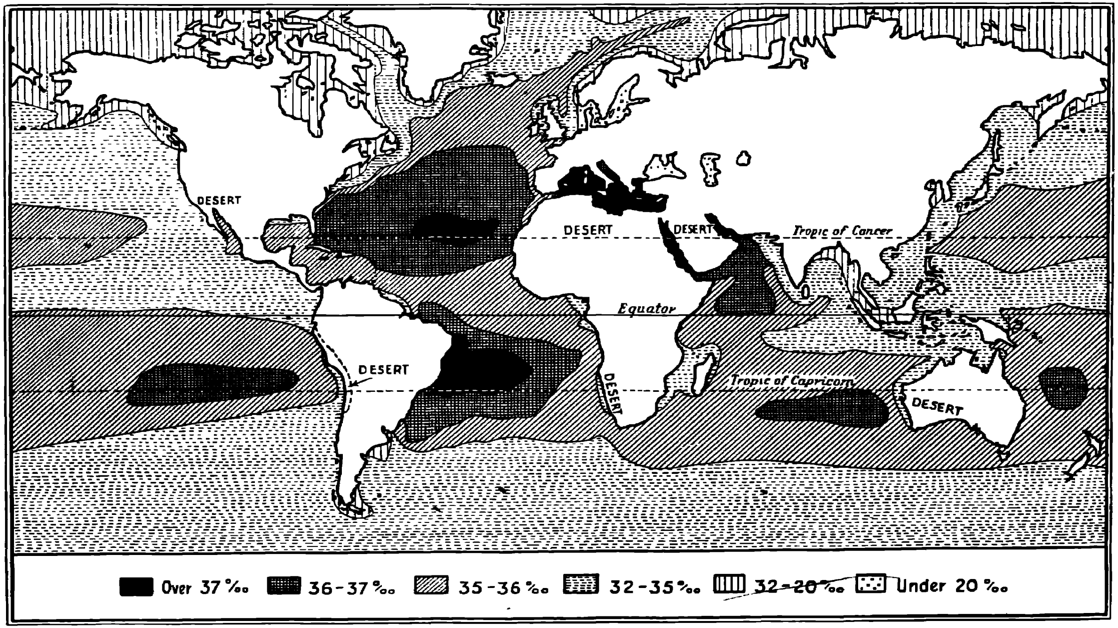


Fig. 56. SALINITY OF THE SURFACE WATER OF THE OCEANS.—Notice that the hot deserts and the areas of greatest salinity lie in the same latitudes.

but below normal, *i.e.* below 35°/$_{oo}$. The approach by sea to the mouth of the Amazon is sometimes determined by the presence of relatively fresh water.

(*b*) North and south of the equatorial area are the Trade Wind belts. It will be shown later (page 181) that Trade Winds are drying winds. Therefore evaporation is rapid in these latitudes (about 20° to 30° N. and S. of the equator). On the land in these latitudes are the great deserts, so that there are relatively few rivers to add a supply of fresh water. In these belts the salinity rises to 37°/$_{oo}$ and over. The map (Fig. 56) shows that the great deserts and the areas of high salinity form two parallel belts around the earth.

Where really large rivers enter the sea in these belts the salinity is lowered, viz. at the mouths of the Zambesi, the Ganges, the Mississippi, and the rivers of Indo-China.

(*c*) Proceeding polewards from the Trade Wind belt, the salinity gradually decreases until, in the poleward sections of the Arctic Ocean it is only from 20°/$_{oo}$ to 30°/$_{oo}$. Here there is less rapid evaporation, more rain, more rivers, and a large supply of fresh water from melting ice.

The Salinity of Partially-Enclosed Seas

The Mediterranean Sea has a very high salinity (40°/$_{oo}$). It is partially enclosed, and its waters do not circulate freely with those of the open ocean. It is in a region of rapid evaporation, particularly during the summer, when, too, many of the rivers become almost dry. The one really large river, the Nile, adds less and less fresh water year by year because of the increasing demands for irrigation purposes. For similar reasons very high salinities are found in the Red Sea and Persian Gulf.

The Baltic Sea contrasts strongly with the Mediterranean. It, too, is nearly enclosed, but it is in a cooler region with a lower rate of evaporation. Some large rivers (Oder, Vistula) empty into the Baltic, and numerous streams flow from the snow-clad mountains of Scandinavia, bringing a constant supply of fresh water. As a result the salinity is only 2°/$_{oo}$, and the water is nearly fresh. One of the important results of this low salinity is that the Baltic Sea freezes readily.

The Black Sea and the Caspian Sea, each fed by rivers of large volume from the Russian plains, also have low salinities. In contrast, the Dead Sea, which like the Caspian is also a region of inland drainage, has a salinity of nearly 240°/₀₀. This is due to several factors, viz.: —

(*a*) Temperatures in the Dead Sea region are high.
(*b*) The rainfall and atmospheric humidity is low.
(*c*) The lake receives water from only a small drainage area.
(*d*) The rate of evaporation is high.

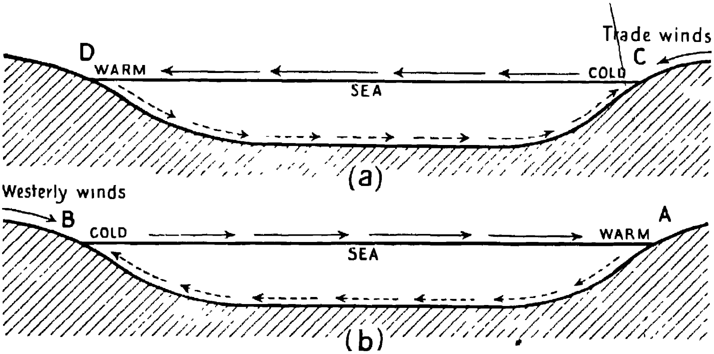


Fig. 57. (*a*) To Show the Effect of Winds on Ocean Temperatures in Latitude 30° N. (*b*) To Show the Effect of Winds on Ocean Temperatures in Latitude 50° N.

Temperature of the Ocean

In general, the temperature of ocean water decreases from the equator, where the surface temperature is over 80° F., to the polar regions where the water is icy cold.

The decrease in temperature polewards is not regular because of the occurrence of warm and cold currents. For instance, in the North Atlantic (about lat. 30° N.) the water on the western side, where there is a surface warm current (the Gulf Stream), will be warmer than on the eastern side, where there is a cold current [Fig. 57 (*a*)]. Further north in the latitudes of the British Isles the conditions are reversed because there is a cold current (the Labrador Current) in the west, and a warm drift (the North Atlantic Drift) on the east [Fig. 57 (*b*)]. These differences in temperature between the

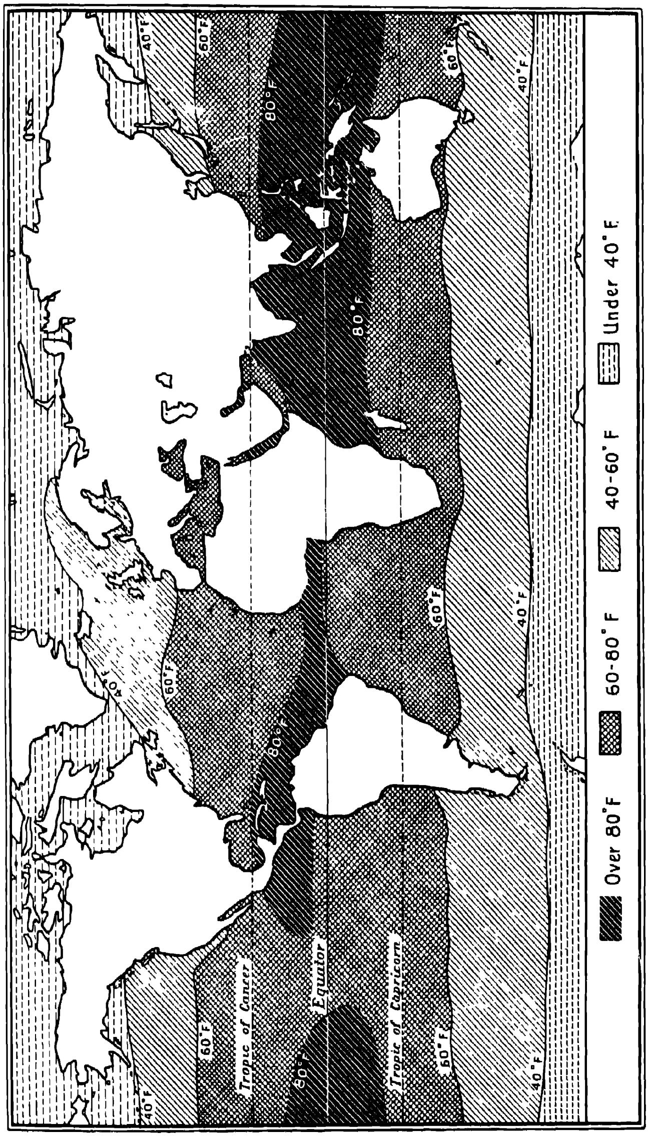


Fig. 58. Mean Annual Surface Temperature of the Ocean.
(Based on the Oxford Advanced Atlas by Bartholomew.)

east and west sides of the ocean are partly due to the influence of winds (Fig. 57) and partly to ocean currents (see page 95).

The temperature also decreases with increasing depth. In the upper layers of water the temperature decreases rapidly downwards, then more and more slowly as the water becomes deeper. For example, the temperature may decrease 10° F. per 100 fathoms in the upper layers of water, but at a depth of 1,000 fathoms the temperature decreases at less than 1° F. per 100 fathoms. The waters of the ocean deeps (below 2,000 fathoms) are uniformly cold, *i.e.* slightly above 32° F.

Submarine ridges, by preventing the free circulation of ocean waters, cause variations in the distribution of temperature. The lower waters of the Mediterranean Sea are 20° F. warmer than the water of the Atlantic Ocean at a similar depth (14,000 ft). This is because the "sill" between North Africa and Gibraltar prevents the penetration of the cold Atlantic waters into the Mediterranean (Fig. 59).

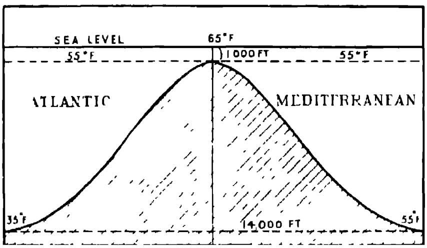


Fig 59. To Show the Effect of the Submarine "Sill" at the Straits of Gibraltar on the Temperature of the Mediterranean Sea.

The Wyville-Thomson ridge which connects Greenland with North Scotland and forms a submarine barrier between the Arctic and Atlantic Oceans has a similar effect. On the Arctic side the water below the level of the top of the ridge is 15° F. colder than water at the same depth in the Atlantic Ocean.

The Red Sea is separated from the Indian Ocean by a bar or sill, the top of which is about 200 fathoms below sea-level. At this depth the temperature of the waters of the Indian Ocean is 70° F. The bar prevents water colder than 70° F. entering the Red Sea. As a result the waters are abnormally warm, and even at a depth of 1,000 fathoms the temperature is 70° F. There are many similar examples, the temperature of enclosed seas always being approximately the same as the temperature of the water at the level of the "sill".

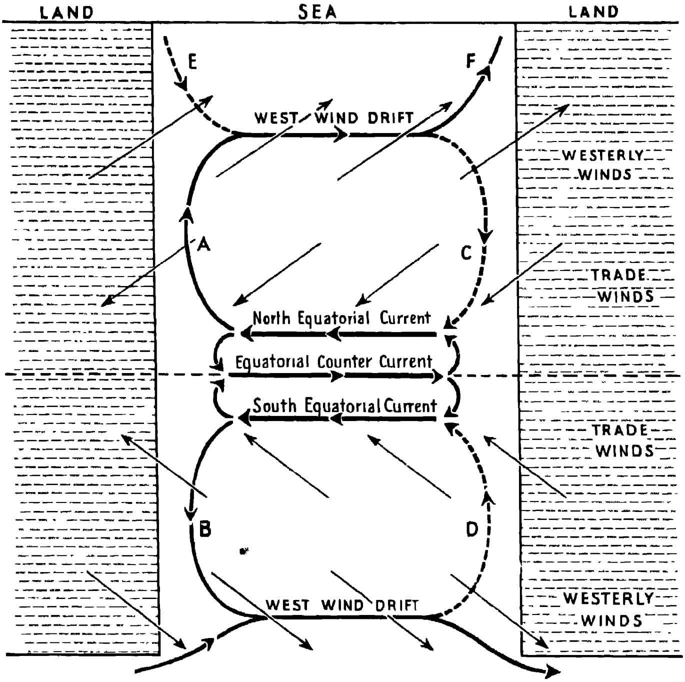


Fig. 60. A DIAGRAMMATIC ARRANGEMENT OF OCEAN CURRENTS.

The Movements of Ocean Waters—Currents and Tides

OCEAN CURRENTS.—The regular movements of water from one part of the ocean to another are called "Ocean Currents".

Ocean Currents are due to a number of much-debated causes, viz.: —

(*a*) Temperature differences and convection.

(*b*) Winds.

(*c*) The shape of the land masses.

(*d*) The rotation of the earth.

It is impossible to separate these factors as they are very much interrelated, but a careful study of Fig. 60 in conjunction with the following explanation will show how and when any one of these factors operates.

Because the water at the equator is warmer and less dense than that in the polar areas, convection currents are set up in the oceans, resulting in a poleward flow of warm, light, surface water and a compensating creep of heavy, cold water through the ocean depths towards the equator. This convective effect is similar to that which produces currents of air (winds) in the atmosphere (see page 172). Just as the winds are deflected by the rotation of the earth so are the Ocean Currents.

In equatorial latitudes the Trade Winds, blowing with great regularity, drive a wide belt of warm surface water westwards. Between the two there is the eastward-flowing Counter Current. Thus there are in the Atlantic, Pacific, and Indian Oceans a North Equatorial Current, a South Equatorial Current, and an Equatorial Counter Current. On reaching the western shore of the ocean the bulk of the warm equatorial water is deflected north and south by the land masses, and this results in the formation of the currents marked A and B.

About latitude 40° N., current A is joined by a south-flowing cold current E, and the temperature of the warm current is thus lowered and the waters are neither abnormally hot nor abnormally cold. The westerly winds drive this water (which is neither warmer nor colder than the surrounding water) north-eastwards across the ocean. It, in turn, reaches a land mass and is deflected (*a*) partly north as current F, and (*b*) partly south as current C. The latter current rejoins the North Equatorial Current so as to produce a clockwise circulation of water in that part of the ocean lying north of the equator. As current F is carrying waters of the warm temperate zone into colder areas, it is relatively warm compared with the surrounding water. Conversely, current C carries water from the middle latitudes into regions of warmer water, and is relatively cold compared with the surrounding sea. It is referred to as cold current although the temperature of its water may actually be higher than the temperature of the warm current. The important fact is that the waters of currents C and F are different in temperature from those of the waters of the surrounding ocean.

In the centre of the "swirls" of the Ocean Currents are areas of stagnant water where sea-weed accumulates. These areas are often referred to as "Sargasso Seas", though the use of this name should be restricted to the North Atlantic area.

PLATE 9

Above: Wind Sculptured Rocks, Arizona. (*Ewing Galloway, N.Y.*)

Below: The Colorado River at Lee's Ferry, Arizona. Note the horizontal bedding of the rocks. In this arid region the absence of surface water has prevented lateral erosion of the valley sides. (*Ewing Galloway, N.Y.*)

PLATE 10

Above: The Pass of Aberglaslyn. Note the typical features of the upper course of a river—the steep valley sides, the boulder-strewn bed, and the swiftness of the flow. (*British Railways.*)

Below: The River Lyn is only a small stream but this photograph shows the damage caused when it burst its banks in 1952 and flowed down the main street of Lynmouth. (*Topical Pr

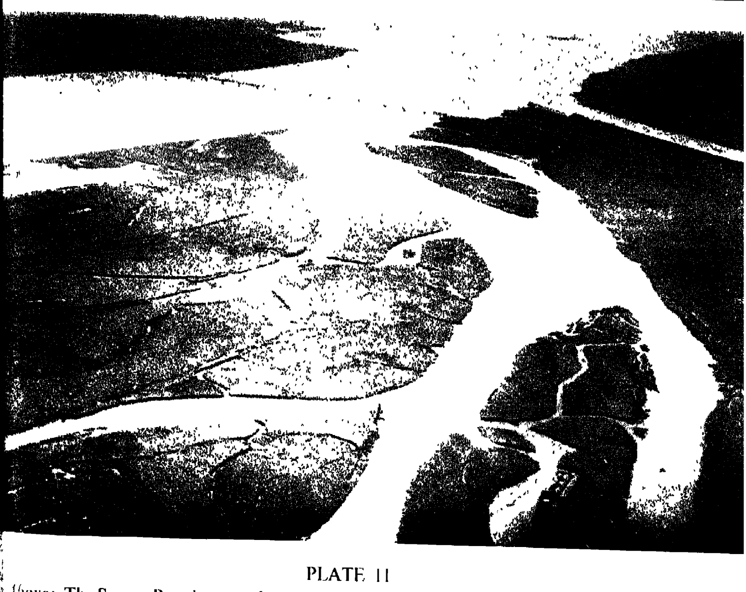


PLATE 11

Above: The Severn Bore between Stonebench and Minsterworth on 3 September 1936, when it reached a height of 10 ft above the normal level of the river. (*Associated Press Photo.*)

Below: The Rhine-Maas Delta. Note the low flat sandy islands, dissected by numerous small creeks, and separated by the large distributaries of the river. (*K.L.M. Royal Dutch Airlines.*)

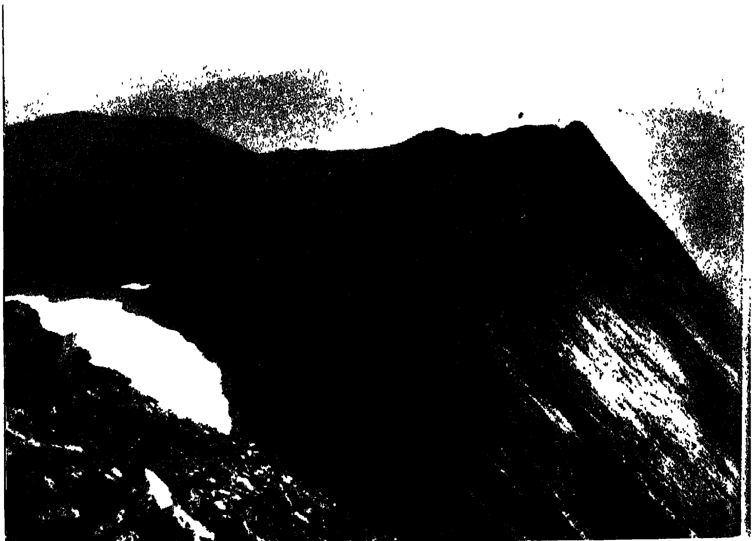


PLATE 12

Above: View up Bowderdale, Westmorland, a glaciated area. Note the rounded contours, and also the erosion produced by the stream since the glacial period. (*Geological Survey, Crown Copyright Reserved.*)

Below: Striding Edge, Helvellyn (see page 127). (*F. Frith and Co. Ltd.*)

South of the equator a similar set of currents may be found, B being a warm current (cf. A), and D a cold current (cf. C). The general movement of the waters is counter-clockwise, contrary to the direction in the Northern Hemisphere.

The land masses do not extend so far from the equator in the Southern Hemisphere as they do in the Northern so that cold polar currents have little effect, and a strong West Wind Drift flows, uninterrupted by land, from west to east in the Southern Ocean. There are no currents in the Southern Hemisphere corresponding to currents E and F of the Northern Hemisphere.

The details of the circulation of water in each ocean may be understood by applying the facts of Fig. 60 to each ocean in turn, modifying the paths of the currents to the coastlines, and giving the correct names to the currents denoted by letters in the diagram, *e.g.* current D is the cold Humboldt or Peruvian Current in the South Pacific Ocean; the cold Benguela Current in the South Atlantic Ocean; and the cold Westralian Current in the South Indian Ocean.

The currents of the Indian Ocean differ slightly from those of the Pacific and Atlantic Oceans. South of the equator the counter-clockwise movement of the waters is the same in the Indian Ocean as in the South Pacific or the South Atlantic. North of the equator, however, between the equator and Southern Asia, the currents are determined by the Monsoons (see page 174). In the summer, when the S.W. Monsoon is blowing, the currents north of the equator flow in a clockwise direction. In the winter, when the N.E. Monsoon is blowing, the currents north of the equator are reversed and flow in a counter-clockwise direction. This causes a disappearance of the North Equatorial Current in winter, the main flow of water being carried eastward in the Equatorial Counter Current.

The effect of winds on the temperature of Ocean Currents is shown in Fig. 57.

The climatic effects of Ocean Currents are discussed on page 150.

TIDES.—During a month's holiday at the seaside it can be observed that the level of the sea varies from day to day and week to week. Twice a day the level of the sea rises and the

tide "comes in", and twice a day the level of the sea falls and the tide "goes out". But the rise and fall of the sea is not always the same, and on the days when it rises to its highest level it also falls to its lowest level. Suppose that on the first day of your holiday the tide rises to level A (Fig. 61) and falls to level D, then each day following, the tide will not advance quite so far as A, nor recede quite as far as D, *i.e.* the difference between high and low water will gradually decrease. At the end of a week it will "come in" or rise to B and fall to C. During the next seven days the height of the high tide will begin to increase and low tide to decrease until it coincides approximately with the levels of A and D. Then once more the tides work back to the levels B and C, and so on. Thus

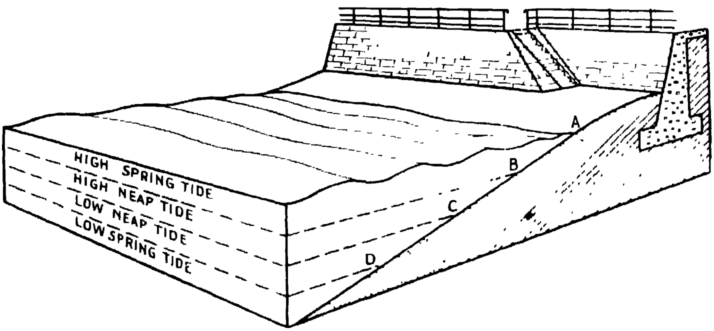


Fig. 61. To Show the Relative Levels of Spring and Neap Tides.

it will be seen that approximately every fortnight the tides rise to a very high level and fall to a very low level. These tides are known as *Spring Tides.* In the intervening weeks the tides do not rise so high or fall so low. These tides are known as *Neap Tides.* Spring tides and neap tides occur every alternate week. It is important to note that tides are caused by the rising and falling of the sea (*i.e.* a vertical movement) and not by the water flowing inshore and receding (viz. a horizontal movement).

The difference in level between high and low water is known as the *amplitude* of the tide. In the open ocean the difference between high and low water is only 2 to 3 ft so that oceanic islands such as the Azores, Mauritius, Hawaii, etc., only experience a very small rise and fall of the tide.

Our islands lie on the continental shelf where the sea is comparatively shallow. Because of this shallowness the lower part of the tidal wave is retarded, and there is a "piling up" of water resulting in very high tides. Tidal effects are rendered more spectacular by shelving shores. The estuaries of British rivers would be mere creeks were it not for the tides. The length of our estuaries accounts for the inland position of many British ports. Teddington (Middlesex) is literally the "Tide end town". In gulfs and very shallow estuaries this "piling up" is further accentuated.

The oceanic tidal wave approaches our Atlantic coasts from the south-west, so that the time of high water gets later and later as one goes eastwards along our southern coast or northwards along our western coast. The average amplitude of the tide around the British Isles is 10 to 20 ft, but in the Bristol Channel it is as much as 30 ft.

As the tides of the shallow seas rise and fall, strong *tidal currents* are set up. These currents help to carry away the accumulation of silt from the estuaries of rivers, and are of great importance to fishermen, who sail out to sea and return to harbour "with the tide". Tides are especially important in relation to shipping, for vessels can only enter or leave a dock at high water, *e.g.* ships have to wait off the bar at Liverpool until high water before they can enter the river.

Off the mouth of the River Rhine there is very little tidal rise or fall. The result is that there are no strong currents to carry away the accumulations of silt, and the Rhine therefore has a delta, a most unusual occurrence where a river flows into the shallow waters of the continental shelf. The rivers flowing into the Mediterranean, where there are no strong tidal currents, all have deltas (viz. Ebro, Rhône, Po, Nile).

Where a tidal current is restricted to a narrow channel as between groups of islands, it becomes very rapid and is often known as a "race", *e.g.* Pentland Race between North Scotland and the Orkney Islands. Other examples are the Alderney Race, and the Maelstrom among the Lofoten Islands off the west coast of Norway.

Causes of Tides.—It has long been recognised that there is a connection between the occurrence of tides and the various phases of the moon, for spring tides occur at "new moon" or

at "full moon", while neap tides occur at the first and third quarters of the moon.

Heavenly bodies attract or "pull" one another. The sun, because of its immense size, should exert a greater "pull" on the earth than the moon does, but distance as well as size has to be taken into consideration, and because the moon is so much nearer to the earth it exerts a greater "pull" than the sun, even though it is so much smaller. Examine Fig. 62.

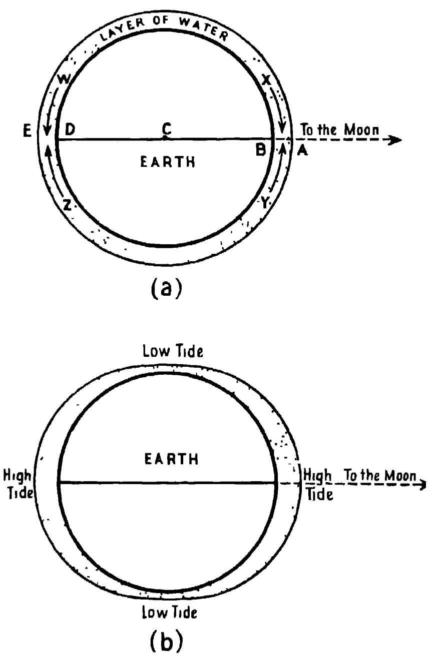


Fig. 62. To Show why there is a High Tide on Opposite Sides of the Earth at the Same Time.

The moon is exerting a "pull" on A. Because A is nearer to the moon than B is, the pull at A is greater than the pull at B. Hence the water, being fluid and responding quickly to the "pull", moves along the direction of the arrows X and Y and "piles up" at A. The pull on B is greater than that on D, and the pull on D is greater than that on E. The water at E is, as it were, being "left behind", and so there is another "piling up" of water along the lines of the arrows W and Z. The result is shown in Fig. 62 (*b*). The moon's pull produces two high tides on opposite sides of the earth and between the crests of the high tides is a trough of water known as the low tide. The sun, however, in spite of the great distance between it and the earth, produces tides in the same way that the moon does, but the solar tides are very much smaller than the lunar

tides. When the sun, moon, and earth are nearly in the same straight line [Fig. 63 (*a*)], viz. at new moon and full moon, spring tides occur. The solar and lunar tides are then coincident (*i.e.* they amplify one another), so that there are very high tides at A and B, and very low tides at C and D.

When the pull of the moon is at right angles to the pull of the sun [viz. at the first and third quarters of the moon, Fig. 63 (*b*)], neap tides occur. The solar and lunar tides then

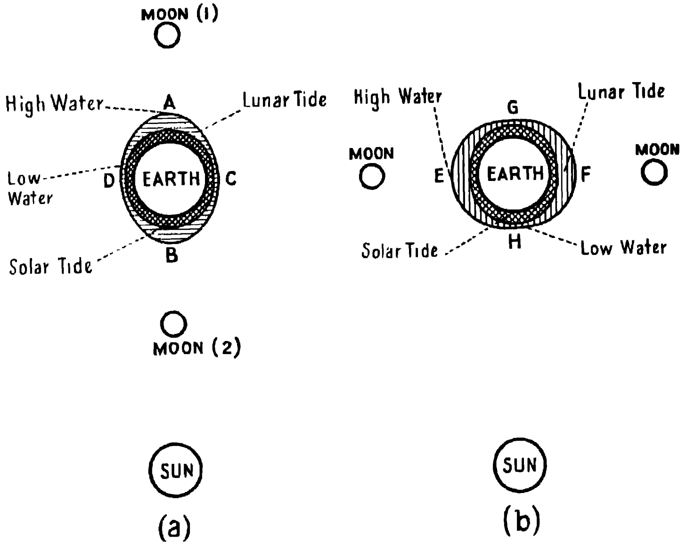


Fig. 63. (*a*) Spring Tides.—Moon (1) is the position of the moon relative to the sun and earth at "full moon", and Moon (2) is its position at "new moon". (*b*) Neap Tides at the First and Third Quarters of the Moon.

partly neutralise one another, so that the tides at E and F, while high, are not as high as those at A and B, and the low tides at G and H are not as low as the tides C and D.

High tides do not occur regularly every twelve hours, but at intervals of 12 hr 26 min., *i.e.* if there is a high tide at 9 a.m. the next high tide will be at 9.26 p.m., and the next at 9.52 a.m. This is because the moon is revolving round the earth in the same direction as the earth's rotation. Suppose that X has a high tide (Fig. 64) due to the moon at A. It takes

24 hr for X to rotate once and come back to its original position. But during this time the moon has moved to position B, so that X has to rotate to Y to experience the high tide again. It takes the moon 28 days to make one complete revolution round the earth, so that XY is $\frac{1}{28}$ of the circumference. If X makes one complete rotation in 24 hr it will make $\frac{1}{28}$ of a rotation in $\frac{24 \times 60}{28}$ min. = 52 min. approx.

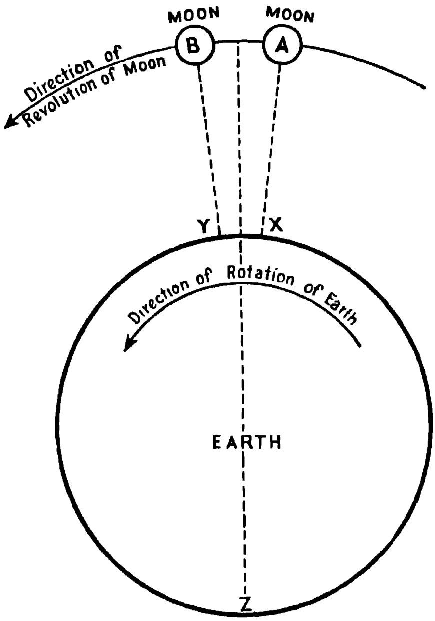


Fig. 64. To Show Why the Time Interval of Consecutive Tides is 12 Hours 26 Minutes.

But during its rotation, the place X would experience a high tide on the side of the earth away from the moon at Z, and this would occur at half of the interval of 24 hr 52 min., viz. at 12 hr 26 min.

In recent years much attention has been paid to the causes of tides and it is now recognised that, although the prime cause of the phenomenon is the gravitational attraction of the moon and sun, other factors, such as the rotation of the earth, the slope of the sea bed near the shore, and the fact that each body of water has its own natural period of oscillation, have to be taken into account in many cases.

It was formerly usual to explain the existence of many areas where the difference between high and low water is small, *e.g.* in the North Sea opposite the mouths of the Rhine, as due to high water reaching the area from one direction (say, up the English Channel) at the same time as low water from another

direction (*e.g.* from the north). In actual fact the waters of the southern North Sea oscillate up and down in such a way that the movement is only small near the Rhine mouths. As a crude analogy we may consider a see-saw. The ends of the see-saw move up and down, but the movement becomes less and less the nearer we get to the fulcrum or axis.

The natural period of oscillation of the waters of the southern North Sea is nearly the same as the approximately twelve-hourly period of the sun and moon's gravitational pull. The oscillation is thus kept up in much the same way as the vibration of a child's swing is maintained by small impulses applied at regular intervals corresponding to the natural period of the swing. Students of physics will recognise this as an example of *resonance*.

Many areas, *e.g.* in the Mediterranean Sea, have natural periods of vibration very different from 12 hr. Such areas are unable to respond to any marked extent to tide-raising forces and hence these areas have practically no tides.

In most gulfs and estuaries the tidal waves enter and make their way up, high water becoming lower and later the further one gets from the mouth, but in funnel-shaped estuaries and gulfs the tidal range often increases as long as the breadth of the waterway is rapidly narrowing, owing to the water being, as it were, cooped up. The mean tidal range at Avonmouth is 33 ft, but only 20 ft at the mouth of the Bristol Channel.

The Gulf of Fundy is celebrated as having up to 50-ft tides at the head of the gulf. Unlike the estuaries and gulfs referred to above, high water is about the same time for all places on the gulf, and the height of the tide is greatest at the head and least, in fact very small, at the mouth. The waters of the gulf have a natural period of almost 12 hr and move rather like one half of the see-saw in our analogy above.

Owing to the slope of river beds and the river water coming down stream, the period during which the tide flows is often much shorter than the period during which it ebbs. In extreme cases the rising tide may come in very rapidly as an almost vertical wall of water called a *bore*. The Severn bore occurs only when there is a high spring tide backed by a strong south-west wind. It is a source of danger to small boats but not to large vessels (see Plate 11). The bore is

known as the *aegre* (or *eager*) on the Trent and as *le mascaret* on the Seine. The Ganges, Yangtse-Kiang, and Amazon also have bores.

At Tahiti in the Pacific the local body of water is able to respond only to impulses from the sun and not to those from the moon. High water is regularly at midday and midnight.

CHAPTER V

THE AGENTS OF EROSION AND LAND FORMS

Introductory

In Chapter III reference was made to some of the major land forms of the world, viz. plateaux, plains, and mountains. These have been modelled and sculptured by a number of natural agents so as to produce many types of scenery, and what may be termed the *lesser land forms.* Scenery varies from place to place, both according to the nature of the underlying rock and the agents modifying it. The natural agents responsible for the modelling of the earth's surface are:—

1. The weather.
2. Running water.
3. Ground water.
4. Ice.
5. The wind.
6. The sea (see Chapter VIII).

The work of these natural agents is threefold. They (*a*) wear away the surface of the land, (*b*) carry away the particles thus removed, and (*c*) deposit the material in some other place. The actual wearing away of the land surface is referred to as *denudation*, or the laying bare of the land. When denudation is the direct result of atmospheric or weather conditions it is referred to as *weathering.*

1. Weathering

Weathering is the process of rock breaking and rock decay produced by the action of rain, temperature changes, frost, and other associated factors. The processes of weathering cause exposed rock surfaces to break and crumble, and in this way material is prepared for transportation by other erosive agents, such as running water, wind, etc. Soils are also formed by the weathering of rock.

(*a*) RAIN.—The work of rain is partly chemical. It dissolves the soluble ingredients of rocks, and washes away the loose particles of insoluble material. The work of rain in

transporting material and carving out gullies or miniature valleys can be well observed on the pit heaps of mining areas. Here, before a mantle of vegetation has had time to develop, each successive rainstorm, beating on the loosely-piled material, carves the gullies deeper and deeper into the sides of the pit heap. The material thus removed is carried to the foot of the slope, partly by the force of the rain, and partly by its own weight acting under the force of gravity. The sides of many active volcanoes, where the constant deposition of new material prevents the growth of a covering of vegetation, show a similar carving into scores of narrow gullies radiating from the mountain top like the spokes of a wheel.

The activity of rain as an erosive agent can be seen in the formation of *earth pillars*. These occur in regions of soft soil or clays, containing scattered blocks of rock. The rain washes away the soft material, except where a small boulder occurs. The boulder protects the underlying soil from the action of the rain. As a result pillars of earth are formed, each one, in the early stages, having a "cap" of rock. Earth pillars are not long-lived, for in time the "cap" of rock falls and the rain destroys the "uncapped" softer material. The most famous examples of earth pillars are to be seen near Bolzano in Italy.

The chemical action of rain is due to the carbon dioxide which it absorbs during its passage through the air. Rain water is therefore slightly acid. Limestone and other forms of calcium carbonate, such as chalk and marble, are soluble in carbonic acid. In limestone areas the slightly acid water, sinking into the ground, forms huge caverns by a slow process of solution (see page 120). The River Thames carries down to the sea in solution 250,000 tons of chalk and limestone every day, equivalent to the removal of one foot of chalk from the whole basin in 150,000 years.

The chemical action of rain on the felspar in granite leads to the formation of *kaolin* or china clay.

(*b*) Heat and Cold.—The result of the alternation of heat and cold can best be seen in deserts where there is a great difference between the day and night temperatures.

During the day, owing to the power of the sun's rays, exposed rock surfaces are heated rapidly, whilst at night the temperature falls perhaps to freezing point. There is, therefore, rapid expansion and contraction every day. These rapid

changes of temperature cause the rocks to crack and split, often with a sharp sound like the shot of a gun. Rocks weathered in this manner are usually characterised by sharp edges and angular shapes. The process of rock splitting continues in desert areas until the rock becomes so finely broken as to constitute sand.

In mountainous areas the broken pieces of rock fall down the mountain side forming long trails of loose fragments known as "screes" (see plates facing pages 64 and 96).

(*c*) FROST.—If water collects in the crevices of a rock and then freezes, the resultant expansion (remember that water contracts on cooling to 4° C. or 39·2° F. and then expands if the temperature falls to 0° C. or 32° F.) makes the cracks wider. The crevice can now hold more water, and the next frost makes the cracks wider still. The action is similar to that of a wedge. Finally, the rock will split. Rocks weathered by frost are also characterised by sharp edges, and good examples of such weathering are to be seen in the Millstone Grit areas of the Pennines, *e.g.* the Roaches near Leek in North Staffordshire, and the Cow and Calf near Ilkley in Yorkshire.

(*d*) THE ATMOSPHERE.—The work of the atmosphere in the weathering of rocks is twofold. *Firstly*, when the air is damp the oxygen and carbon dioxide in the atmosphere combine with substances in the rocks to form oxides, hydrates, and carbonates. These are often softer than the original rock and more easily soluble. Chemical processes also produce rock-decay such as can be observed on old tombstones, or on buildings, *e.g.* the Oxford and Cambridge colleges, where the surface of the stone is crumbling. The carvings on Cleopatra's Needle have become far less distinct (as a result of weathering and rock decay) during the sixty-odd years that the monument has been on the Thames Embankment, than they did throughout the 4,000 years that it stood in the dry climate of Egypt.

Secondly, the atmosphere has a mechanical action which is the result of its movement—wind. When the wind blows fine grit or sand against exposed rock surfaces fantastic weathering results, for the dust-laden wind acts as a sand-blast and erodes the rock very unevenly according to its hardness or softness. Brimham Rocks, near Harrogate in Yorkshire, illustrate the erosive effects of the wind. This action is most easily

observed in sandy regions. At some towns on the west coast of the United States, windows facing the shore have become so worn that they appear to be made of frosted glass. Trains that cross desert areas have to be repainted very frequently, because of the effect of the dust-laden wind. For many centuries only the upper portion of the Sphinx was exposed, the lower portion being buried beneath the sand. When the sand around the base was removed it was found that the carving of the lower part had been well preserved in contrast to the carvings on the upper part which had been exposed so long to the desert winds. In many seaside areas cliffs are fantastically weathered as a result of the wind-blown sand.

(*e*) PLANTS AND ANIMALS.—Plants and animals also help in the process of rock-breaking. Roots of trees sometimes grow in cracks in the rock. As they grow they act like wedges and cause pieces of rock to break away from the main mass. Burrowing animals and earth worms also help to loosen the soil. On the other hand, a top covering of grass or other natural vegetation is a considerable protection to the soil beneath from erosion, especially wind erosion (see pages 128-30).

2. The Action of Running Water

Rivers are the most important of all the natural agents which help to model the land surface. Their work is twofold. Firstly, they wear away the land; secondly, they carry away and re-deposit the eroded material. The nature of the work of the river at any point in its course depends on the volume and the rate of flow. The latter in turn depends on the gradient or slope of the river bed. When the river flows rapidly it is primarily engaged in erosion, but where its course is slow its main work is that of deposition. Rivers flow more rapidly when in flood, hence erosion is then rapid and floods may be very destructive, as for example in the Lynmouth disaster of 1952 (see Plate 10).

A river in flood has a muddy appearance because it carries fine particles of mud or silt which it has removed from its banks and bed. As long as the river flows quickly, this fine silt is carried in suspension, but when the speed of the stream slackens part of the load of silt is dropped.

On reaching the sea the rate of flow is further checked, and the silt is deposited on the sea floor. In this way rivers are

constantly removing material from the land, thus lowering its level. The material which is removed is eventually deposited on the ocean floor, and the sea therefore tends to become shallower. This effect is clearly seen in the Gulf of Mexico and at the head of the Adriatic Sea. It has been estimated that the River Mississippi and its tributaries carry over a million tons of silt to the Gulf of Mexico daily. At this rate of erosion the whole basin of the Mississippi would become 1 ft lower in six thousand years.

Most rivers can be considered to have three sections:—

(*a*) The Torrent or Upper Course, where the gradient is steep (*i.e.* about 50 ft or more per mile).

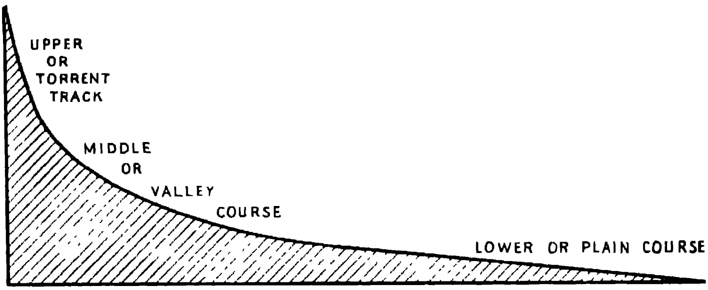


Fig. 65. PROFILE OF RIVER TYNE (VERTICAL SCALE EXAGGERATED ABOUT TEN TIMES) TO SHOW THE THREE SECTIONS OF THE COURSE OF A RIVER.

(*b*) The Middle or Valley Course, where the gradient is about 10 ft per mile.

(*c*) The Lower or Plain Course, where the gradient is often less than 1 ft per mile (Fig. 65).

The proportion of the length of these sections is not the same in all rivers. Some, such as the streams of Norway and Western Scotland, are swift-flowing almost to the sea. They have only a small section of plain, and are often more important for the development of hydro-electricity than for navigation and the agricultural development of lowland areas. Other rivers, such as the Amazon, Ganges, Mississippi, Thames, Seine, Elbe, etc., have more extensive plain courses. Their upper courses are relatively short and they have long plain courses with extensive areas of lowland. The natural

tendency of all rivers is, in course of time, to decrease the proportion of the torrent section and increase the extent of the lowland areas.

THE UPPER COURSE OF A RIVER.—In this section of a river the work is primarily that of erosion or destruction. The swiftness of the current and the boulders which it carries along are constantly wearing away the bed of the river. Because of this the valley is being lowered more rapidly than it is being widened, hence the characteristic valley of the torrent course is steep-sided. Tributaries, if any, are all short and swift. In some rivers, because of the hardness of the rock, the valleys have almost perpendicular sides and are called ravines, *e.g.* the Aar Gorge in Switzerland, the Severn Gorge at Ironbridge, etc. Typical torrent courses of rivers may be observed in the glens of Scotland, the Welsh Highlands, etc. The principal value of streams in their upper courses is for the development of hydro-electric power (see Plate 7).

THE MIDDLE COURSE OF A RIVER.—This is best considered as being transitional between the upper and lower courses. The work of the river in this section is both constructive and destructive. Because the rate of flow is slower, erosion is not so rapid, but the river bed is still being lowered by the grinding action of stones, etc., which the river rolls along. Some deposition takes place along the sides of the river where the current is slowest, and during floods thin layers of silt or alluvium are spread over the lowland on each side of the river. Instead of taking the most direct course possible, the river begins to meander. The valley is being widened as well as deepened, and tributaries are longer and more gently flowing. The valley walls are not so steep as in the upper course, and instead of rising quickly from the edge of the stream, there is a "flat" of varying width between the river and the valley sides. In such valleys, in contrast to the upper course, agriculture is possible. In the temperate zone farmers usually till the valley flats and use the hillside for grazing. This is well illustrated in that part of the Severn Valley, which lies in Wales, between the English border and Newtown, or in the dales of Yorkshire.

THE LOWER COURSE OF A RIVER.—In this section the work of the river is almost entirely constructive. The river flows

slowly, meandering in great loops over wide plains. Tributaries are long and slow-flowing, and the valley walls are usually so far from the main stream that the "Valley Form" is difficult to recognise. Floods result in the widespread deposition of alluvium. Since this is a well-mixed, finely-graded, stoneless soil, it is exceedingly fertile, and most of the great river lowlands of the world are associated with a high degree of agricultural development, *e.g.* the plains of the Ganges, Hwang Ho, Mississippi, etc. In this section most rivers are valuable for navigation, and in arid regions, for irrigation, because of the relative ease with which the water can be spread over the flat plains.

The current of a river is slowest at the sides and bottom because of the retardation due to friction. In the lower course the least slackening of speed at once results in deposition so that, in many rivers, silt accumulates at the bottom and sides

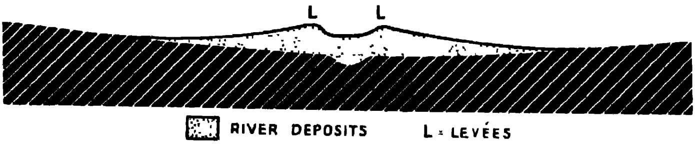


Fig. 66. To Illustrate the Raising of a River Bed Above the Surrounding Plains.

of the river. After a long period of such deposition the bed of the river is raised, and it flows between raised banks along a bed which is at a higher level than the plains on either side (Fig. 66). Such raised banks or embankments are known as "levées", and are to be found in the lower courses of the Mississippi, Po, Hwang Ho, Yangtse-Kiang, etc. Because they are composed of soft earth, levées can rarely stand the pressure of excessive flood water, and often give way, the river water invading adjacent plains causing disastrous floods such as those of the Hwang Ho. In England, the rivers draining to the Wash are liable to floods for similar reasons. To prevent flooding, levées are often strengthened with cement and masonry, but even such measures were ineffective in preventing the terrible Mississippi floods of 1929 and 1937.

Another great characteristic of the lower course of the river is the development of *meanders*. When a river begins to swing in large curves the current strikes the banks alternately,

first on one side and then on another. As a result [Fig. 67 (*a*)] the banks are worn away at the point X, and silt carried downstream is deposited at the points Y on the sides where the current is less strong. The outer banks (X) of a meander are often very steep, while the inner banks (Y) are gently shelving and low. Gradually the banks are worn back at X, and the curves of the river become more pronounced [Fig. 67 (*b*)]. In time the loops or meanders assume the shape shown in Fig. 67 (*c*). The stream is now cutting away its banks not only at the points X, but also at the points W. At length the strip of land between W_1 and W_2 becomes so narrow that the river breaks through and the meander loop Z is left [Fig. 67 (*d*)]. This horse - shoe - shaped strip of water is known as an *oxbow* lake. The oxbow lakes of the Mississippi and Murray are famous, but many smaller examples can be seen along the sides of brooks and streams in our own country. The continual accumulation of silt within the river loops helps in the process of formation of the alluvial plain.

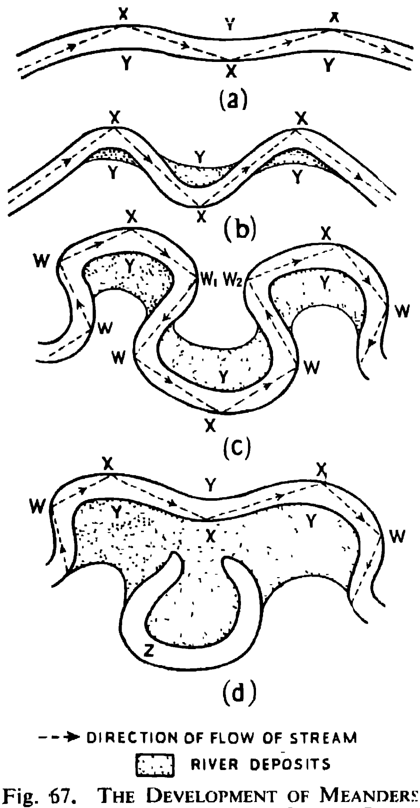


Fig. 67. THE DEVELOPMENT OF MEANDERS AND THE FORMATION OF AN OXBOW LAKE.

DELTAS.—Some reference has already been made (pages 108-9) to the way in which rivers deposit much of their load of

sediment in the sea. Such accumulations of silt are known as *deltas*, the name arising from the fact that many deltas are triangular resembling the Greek letter Δ in shape. Deltas are also formed where rivers enter lakes. Even in small mill-pools the process of delta-building is to be seen at the point where the mill-stream enters the pool. Lakes act as filters to a river, and the waters of streams leaving a lake are much clearer than those of streams entering a lake. The clearness of the Rhône waters where they leave Lake Geneva contrasts sharply with the muddy silt-laden river which enters the lake.

A number of conditions are necessary for delta formation, viz:—

(*a*) The river should have a mountainous upper course where erosion is rapid. The delta-building power of a river is greatly increased if it has a number of tributaries which also gather a considerable load of sediment.

(*b*) There should be no strong tidal currents to remove the accumulation of silt from the mouth of the river. Rivers flowing into seas with a large tidal range (*e.g.* on the continental shelf) have deltas only where special conditions occur, *e.g.* the Rhine (see page 99). Rivers flowing into tideless seas such as the Mediterranean have deltas.

(*c*) If there are large lakes in the course of a river much of the sediment is removed before the river reaches the sea.

(*d*) The river should have a long plain or lower course so that its current will have slackened before it reaches the sea. Where the gradient of the lower course of the river is swift the strength of the current may be sufficient to carry the sediment well out to sea beyond the mouth of the river.

The Rhône has a mountainous upper course in the Alps, but Lake Geneva robs the river of the silt which it has gathered. In spite of this the Rhône has a large delta, for after leaving Lake Geneva it receives the silt-laden waters of tributaries (*e.g.* Rivers Isère and Durance) which drain the Western Alps. Their speeds slacken on the plains of the lower Rhône, and the river finally enters a sea devoid of strong tidal currents.

The Mississippi does not rise in a mountainous area, but in the Central American plains to the west of the Great Lakes. Its largest tributaries such as the Missouri, Cheyenne, Platte,

Arkansas, etc., rise in the Rocky Mountains and, being swift-flowing, collect the necessary sediment for delta-building. The lower course is long and slow and the river enters the Gulf of Mexico where the tidal currents are not strong. The Mississippi delta is not, like the majority of deltas, triangular, but is "bird's foot" shaped. When a delta is formed at the head of a gulf (*e.g.* the Colorado delta at the head of the Gulf of California), its shape is determined by the shape of the coast. Part of the English Fenland may be considered as deltaic in origin. The plains of Iraq are really the deltaic lands of the Tigris and Euphrates, and much of the northern plain of Italy may be considered as the delta of the River Po.

The rate of growth of deltas varies according to the rate at which silt is deposited. The Rhine delta is advancing seawards at the rate of about one mile per century. Adria, a town in the deltaic region of the River Po, is now 12 miles inland but was a port in Roman times.

The surface of a delta is extremely flat, and is usually crossed by a number of streams which debouch from the main river, forming an intricate drainage network. These streams are known as *distributaries* (see Plate 11).

The soil of deltas is extremely fertile because of its finely-divided state, its varied composition, and the humus (decaying vegetable matter) which it contains. Deltas of the temperate zone, when reclaimed and drained, support profitable agricultural settlements, *e.g.* Holland. In hot lands deltas provide excellent rice-growing areas, *e.g.* the Nile, Yangtse-Kiang, Mekong, and Irrawaddy deltas. The Ganges delta is important for its jute.

RIVER VALLEYS.—It will be convenient to consider here the question of river valleys, whose shape varies according to:—

(i) The section of the river in which the valley occurs.

(ii) The age or maturity of the river.

(iii) The nature of the rock.

(iv) The climate—particularly the rainfall of the area.

(v) Erosive agents.

(i) It has already been shown (pages 108-13) that valleys in the upper, middle, and lower courses vary in shape. Where deepening is taking place more rapidly than widening, the

valley section is that of a steep-sided letter V (A) (Fig. 68). In the middle course of a river, widening of valleys is more rapid, and the V-shaped section becomes flatter (BB′). In the lower course valley widening has taken place to such an extent that the V-shape is so flattened as to be hardly recognisable (CC′).

(ii) In its youthful stage a valley is narrow and steep-sided. As the level of the bed of the stream becomes lower, vertical erosion becomes less rapid, and the valley develops in width. In its mature stage the valley is wide and flat. It will be seen that the progress from youth to maturity in valley development, is similar to the changes in valley shape between the upper and lower course of a river (Fig. 68).

(iii) Where the rock is so hard as to resist widening, and where the speed of the stream causes rapid vertical erosion, a valley is formed with almost perpendicular walls rising steeply from the water's edge. Such valleys are known as *ravines or gorges*. In areas composed of limestone, valleys

Fig. 68. VALLEY SECTIONS.

also have very steep and sometimes almost perpendicular sides: *e.g.* Gordale Scar (near Malham in Yorkshire), the Winnats near Castleton, and the Cheddar Gorge in the Mendips. The widening of valleys is very largely the work of the surface "run-off" of rain water. This gradually wears away the valley sides and decreases their slope. As limestone is porous, much of the rainfall immediately percolates into the ground and does not run off as surface water. Hence the widening of limestone valleys is extremely slow and steep-sided valleys result. (See Fig. 13 and also frontispiece.)

(iv) In arid regions there is no rainfall to assist in the widening of valleys, and the vertical erosion of rivers crossing plateau areas results in deep, steep-sided valleys called *canyons*. The most famous canyon is that of the River Colorado in the United States. It is a mile deep for a distance of about 200 miles. The Orange River, which flows across the South African plateau, has a well developed canyon in

that part of its course which passes through the arid and semi-arid lands bordering the Kalahari desert. It should be noted that deep canyons are only found in plateau areas. Rivers can only erode their beds down to a level just above that of the sea or of the lake into which they flow. A river flowing across a plateau 5,000 ft above sea-level can erode a canyon nearly 5,000 ft deep, but a river flowing across a plain 100 ft above sea-level can only make a valley nearly 100 ft deep.

(v) As a result of glacial action (see page 126) a valley section may be changed from the normal V-shape to that of a U-shape.

RIFT VALLEYS.—Rift valleys differ considerably from those which have been formed by the agents of erosion such as running water because they are the result of earth movements. They bear little relation to the rivers which they may contain. They may in fact accommodate several rivers, and have no outlet to the sea. Portions of their floors may be above or below sea-level.

It was for a long time accepted that rift valleys resulted from the subsidence of a strip of the earth's crust between two parallel sets of faults. For example, the rocks might have been arranged as in Fig. 49. Then owing to faulting along the lines AB and CD, the strip of the earth's crust lying between the faults was lowered relatively to the land on either side. This may have been due to the depression of the portion of the crust lying between the faults or to the elevation of the adjoining land, or to a combination of both movements. According to Wegener (see Chapter III), the formation of rift valleys may be readily explained on the assumption that they represent fractures in the earth's crust which have been widened by the drifting apart of portions of the land masses.

The finest example of a rift valley is that stretching southwards from the Taurus Mountains through the valley of the Jordan and the basin of the Red Sea, almost to the Zambesi River. Other examples are the Central Lowlands of Scotland, the Rhine Valley between Basle and Bingen, and the depression containing Spencer Gulf and Lake Torrens in South Australia.

The floors of these valleys are not always flat, as is well seen in the rift valley of East Africa, which contains many

deep lakes. Frequently, however, the irregularities of the valley floor are buried beneath thick deposits of fertile alluvium, as in the Rhine rift valley. The steep-sided character of much of the African rift valley is due to its relative newness, but in other similar valleys of greater age, the weathering agents have greatly reduced the slopes of the sides.

3. The Work of Ground-Water

Some of the water which falls as rain runs over the surface of the ground to the nearest brooks and streams, some evaporates, and some sinks into the ground and becomes *ground-water*. The amount of ground-water varies considerably from place to place, and is obviously greater where the surface rock is porous such as limestone and chalk than it is in areas of non-porous or impermeable rock such as clay.

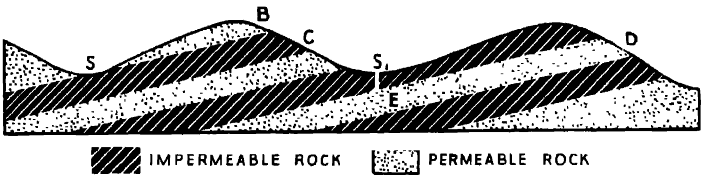


Fig. 69. The Formation of Springs.

Ground-water is responsible for the formation of springs, wells, geysers; it helps to cause landslides; and in limestone areas it is associated with caverns and a number of related phenomena.

Springs.—Water which flows out of the ground is known as spring-water. Two cases of spring formation are shown in Fig. 69.

(i) Rain falling on the porous rock B gradually percolates until it reaches the impermeable layer C. As it can percolate no further it flows along the top surface of the impermeable rock until it reaches the surface of the ground at S, there forming a spring.

(ii) Rain falling on the outcrop of porous rock at D moves along that layer until it reaches a crack or joint which leads to the ground surface S_1, the weight of water pressing down between D and E forces the water up the crack and a spring is

formed at S_1. This spring will only flow when the level of ground-water in the porous layer D is higher than the ground level at S_1. Some springs are warm or hot, as a result of the contact of the ground-water with rock that is not yet cold. Hot springs are common in volcanic regions, or regions where volcanism is slowly disappearing, such as Yellowstone Park in the United States, or in North Island, N.Z. Spring-water contains mineral salts in solution. When the springs contain a very high percentage of dissolved minerals, or an uncommon mineral, they are called *mineral springs*. Some mineral springs have medicinal properties, and give rise to famous watering places or spas, such as Carlsbad in Germany, Buxton and Harrogate in England, and Vichy in France.

Eruptive hot springs known as *geysers* are found in Yellowstone Park (U.S.A.), Iceland, and North Island, N.Z.—all regions of recent volcanic activity.

The "eruption" of a geyser consists of the ejection of a column of hot water at intervals. The intervals are sometimes extremely regular as in the case of Old Faithful in Yellowstone Park which erupts every hour, and the "Minute Man" which erupts every minute.

It is thought that geysers are caused in the following way. There is an opening in the ground leading down to great depths. Ground-water collects in this opening, and owing to the heat of the rocks the water rises to a temperature far above 212° F. Although at sea-level the boiling point of water is 212° F. (100° C.) it must be remembered that the increased pressure due to the overlying column of water raises the boiling point at levels below that of the earth's surface. By convection, some of the superheated water commences to rise, and owing to a fall in pressure the water "flashes" into steam and immediately expels the water above it. Some of the hot water falls back into the opening and the process is repeated. Around the top of a geyser there is usually a small mound depressed in the centre. This mound is composed of mineral matter deposited by the hot water. As the rock below the surface becomes cooler the geyser will cease to erupt.

ARTESIAN WELLS.—Artesian wells are special types of springs where the hole through which the water issues is made

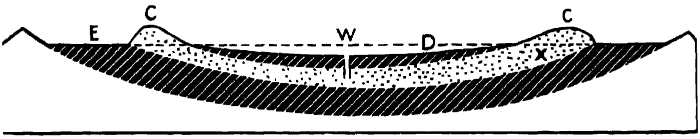
by man and not by nature. They are possible only where certain conditions of rock structure occur.

(i) The rocks should be synclinal as in Fig. 70 (*a*), or dip as in Fig. 70 (*b*).

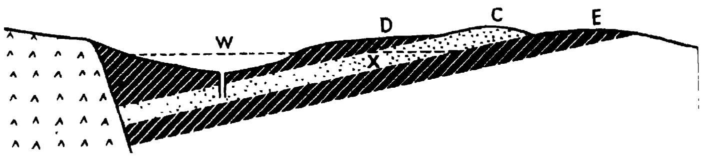
(ii) There should be a layer of permeable rock C between two layers of impermeable rock D and E.

(iii) The layers of porous rock should be exposed at the surface of the ground.

(iv) There should be a copious rainfall to give a supply of ground-water.



(*a*)



(*b*)

IMPERMEABLE ROCK EG. CLAY
PERMEABLE ROCK EG CHALK
OLD HARD ROCK

Fig. 70. ARTESIAN WELLS.

The rain water falling at C percolates through the permeable layer. It cannot pass downwards through the impermeable layer E, and the layer D prevents the water passing upwards until a hole is bored at W. Provided that the level of the ground-water in the porous rock is higher than the top of the boring, the pressure of the ground-water in the porous layer will force the water up to the surface. If the level of the ground-water is as high as the dotted line X, then the water at W will rise almost to the level of the dotted line shown below W in each diagram. As the level of the ground-water falls, the water in the boring rises less and less high until it

only comes part of the way up the boring. Pumps are then used to lift the water to the surface. Fig. 70 (*a*) illustrates the conditions which give rise to artesian wells in the London Basin, the porous layer being composed of chalk. Some of the water supply of London is obtained from such wells. Fig. 70 (*b*) illustrates the physical conditions giving rise to artesian wells in Australia. There are many artesian areas in Australia, but the largest comprises the greater part of the Central Plains. The depth of artesian wells varies from a few feet deep to thousands of feet.

Artesian water is of great importance to the sheep farmers of the interior plains of Australia, but unfortunately much of it contains too much dissolved mineral salt to be of value for the irrigation of crops. The name "artesian" is derived from Artois, a department of North-Eastern France where there are many artesian borings.

LANDSLIDES.—Ground-water increases the weight of the rock or soil which holds it. Sometimes a heavy, water-logged mass of earth slides down a steep slope. This sliding is due to the increased weight. Landslides are most prevalent where there is an underlying layer of clay which, when moist, provides a smooth surface over which the mass can move with relative ease. Landslides are common in the South Wales coalfield and along the coast of South-East Yorkshire and of Norfolk. A few years ago, after a period of heavy rain, the railway embankment between Smethwick and Birmingham collapsed.

THE EFFECTS OF GROUND-WATER IN LIMESTONE REGIONS.—As stated earlier in this chapter, rain water containing carbon dioxide will dissolve limestone, and this results in a number of features characteristic of limestone areas.

(*a*) *Caverns*. Percolating rain water, by the process of solution, enlarges the joints and fissures of limestone and makes it more porous so that a greater and greater volume of water can be absorbed. In course of time so much limestone is dissolved that underground caves are formed. The caves are often connected by underground passages. In the neighbourhood of Mammoth Cave (Kentucky) there are nearly 200 miles of such caves and tunnels. The hills of North Derbyshire

are honeycombed with caverns, such as the Peak, Speedwell, and Blue John Caverns. The Jenolan Cavern in New South Wales is one of the largest in the world.

(*b*) *Stalactites and Stalagmites.* Ground-water containing limestone in solution continually seeps through the roof of limestone caverns (Fig. 71). As a drop of this weak limestone solution "hangs" on the roof of the cave, some of the water evaporates leaving a small deposit of limestone on the roof. The remainder of the drop falls to the floor of the cave. This also evaporates, leaving behind a very thin layer of limestone. This process continues for thousands of years until pendants (stalactites) and pillars (stalagmites) of limestone are formed.

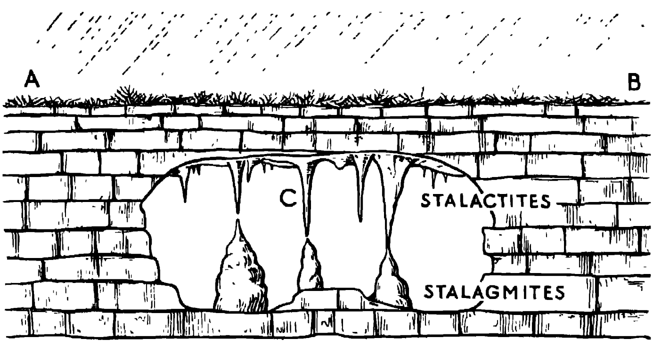


FIG. 71. THE FORMATION OF STALACTITES AND STALAGMITES.

The rate of formation varies a good deal, some perhaps less than 1 in. in 1,000 years, others much more rapidly. Stalactites are usually long and slender, but stalagmites are wider and shorter. Often a stalactite and a stalagmite join, forming a complete pillar from the floor to the roof of a cave.

(*c*) *Underground Drainage.* Rivers in limestone areas often disappear underground through holes called "swallow holes" or "pot holes", and flow for many miles through subterranean passages and caverns before they again reach the surface. Such a stream flows underground at the foot of a cliff at Perryfoot, about four miles east of Castleton on the road to Buxton. It reappears in the Peak Cavern in Castleton after an underground journey of nearly 6 miles. An excellent example of a

swallow hole is Gaping Ghyll near Ingleton, Yorkshire. It is 365 ft deep, and into it flow the waters of Fell Beck.

(*d*) *Dry Valleys.* Streams which once flowed over the surface forming valleys, now disappear underground, their waters flowing along the joints and crevices of the rock and through underground channels. The surface valleys now have no streams in them except during very rainy periods, when the volume of water is too great for the swallow hole to take. A well-known one ends at the top of Malham Cove, and during a very wet season some years ago, a stream actually occupied the valley. Great Rocks Dale, about 4 miles east of Buxton, on the road from Buxton to Sheffield, is a dry valley, and there are many good examples in the Cotswolds and the Chilterns, *e.g.* the Misbourne near Aylesbury.

The characteristic valleys of limestone regions are deep and steep-sided (see page 115).

(*e*) *Subsidence.* When the roof of a subterranean passage collapses the result is often a long, steep-sided gorge. Such a collapse possibly assisted in the formation of the Cheddar Gorge (see frontispiece) and other limestone gorges.

Subsidence sometimes results in a hollow or depression. At the bottom of this the weathering of the limestone produces a clayey soil. Such hollows, known as *dolines*, are, where sufficiently large, suitable for agriculture, in contrast to the greater portion of limestone country, which, covered with poor grass due to the lack of surface moisture, is only suitable for pastoral occupations. In the mountains of Yugo-Slavia dolines provide the best farming lands, and the villages are located on them. The Dolomite mountains are composed of a special type of limestone which weathers into fantastic shapes, reminiscent of ruined castles, pillars, etc. As a result of weathering the surface of exposed limestone is often criss-crossed with cracks and fluted ridges known as *clints*.

The mountains to the east of the Northern Adriatic Sea are composed of limestone, and all the characteristics of limestone areas can be seen there. This region is called the Karst, and its name is now applied to all limestone areas having similar features. Other regions with well-developed karst topography are the South Pennines in England; parts of Western Ireland; the western edges of the Central Plateau of France

(the Causses), in the neighbourhood of the River Lot and the River Tarn; parts of the Blue Mountains in Australia; and part of the western slopes of the Appalachian Mountains.

4. The Work of Ice

The work of ice as an erosive agent is now restricted to high mountain areas and the Polar regions, but at various periods during the earth's history immense sheets of ice have covered large areas of the temperate zone. During the last of such cold periods, generally known as "The Ice Age" or "The Glacial Epoch", sheets of ice, possibly a mile thick in places, covered (1) Canada and much of the north of U.S.A., and (2) Northern Europe including all that part of the British Isles which lies north of an irregular line from the mouth of the

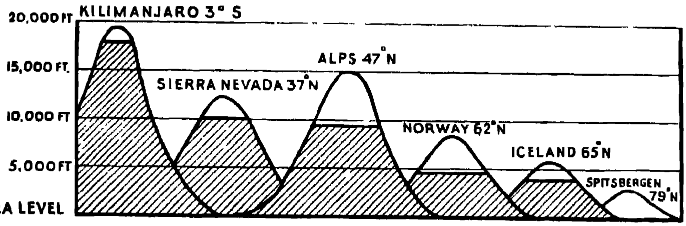


Fig. 72. To Show the Change in the Height in the Snow Line from the Equator to Spitzbergen.

Shannon to the mouth of the Thames. Such masses of ice, known as *ice sheets* or *continental glaciers*, exist now only in Arctic (including Greenland) and Antarctic regions. Glaciers found in mountainous areas such as the Alps, Rockies, Himalayas, etc., where the peaks project above the level of the ice in the valleys, are known as *valley glaciers*.

In high latitudes and high altitudes precipitation is generally in the form of snow. The line above which it is too cold for snow to melt even in summer is called the *snow line*. (The snow line is at sea-level in Polar regions, at 6,500 ft in the Pyrenees, and 18,000 ft in the Andes near the equator, Fig. 72.) Above the snow line fields of snow are found. These are called *nevés*. Because of the accumulation of snow, the bottom layers are subjected to such great pressure that ice is formed, and this, by the force of its own weight acting under

gravity, moves slowly down the mountain sides. In plateau areas it spreads out in all directions as an ice sheet, but if the snow field is at the upper end of a valley the ice moves down the valley as a valley glacier. In temperate and hot countries glaciers melt on reaching lower levels, always some distance

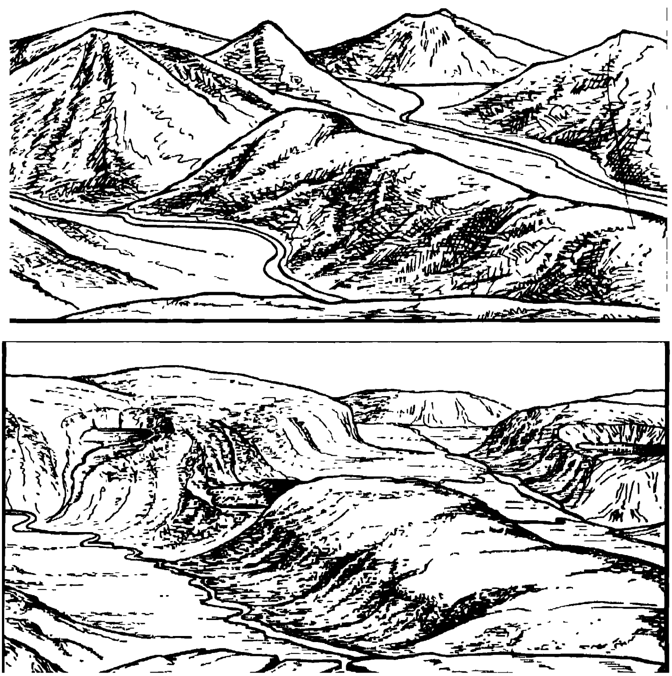


Fig. 73. EFFECTS OF GLACIATION IN A HIGHLAND AREA.—The upper drawing shows a highland area before sheet glaciation and the lower the same area after glaciation. See also plate facing page 113.

below the snow line, and thus become sources of rivers (*e.g.* Rhine and Ganges), but in cold countries the ice creeps down to the sea, where great masses break off and float away as icebergs. Some of the glaciers of Greenland move at the rate of 50 ft a day, but the Alpine glaciers move more slowly—only 20 in. a day on an average.

The work of glaciers, like that of rivers, is twofold; they (*a*) wear away the land over which they pass, and (*b*) re-deposit the eroded material.

As a glacier moves slowly forward it collects loose rock débris and wears off projecting points of rock over which it passes. The rock material thus embedded in the underside of the glacier helps in the wearing away of the land, just as though the glacier were a gigantic piece of sand-paper. In this way mountains are rounded, valleys deepened and widened, and in general the ruggedness of a highland area gives place to smooth rounded outlines (Fig. 73). Note, however, that if the glaciation is confined to the valleys the outline of the peaks above the level of the glaciers becomes even more jagged than before owing to the cutting back of their sides by the ice beneath (see page 127 below).

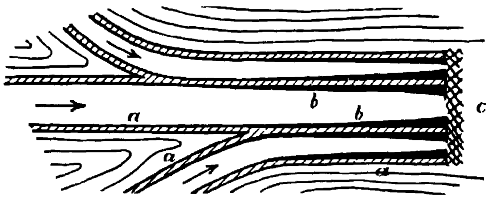


FIG. 74. A GLACIER AND TRIBUTARIES.
aa. Lateral moraines. *bb*. Medial moraines. *c*. Terminal moraine.
---→ Direction of flow. —— Contour lines.

Valley glaciers undercut the valley sides, and rock fragments fall on the sides of the glacier to form a ridge of loose material called a *lateral moraine* (Fig. 74). When two valley glaciers meet two lateral moraines join to form a *medial moraine*. The material carried along underneath the ice, together with rock waste that falls through the crevasses (cracks in the surface of the glacier) forms the *ground moraine*. At the end of a glacier, the accumulation of eroded material is known as the *terminal moraine*. Sheet glaciers have large ground and terminal moraines. When the end of the glacier recedes, owing to rapid melting, morainic material or glacial drift is left behind unevenly distributed over the surface of the land.

Drift topography is characterised by hillocks and mounds, smooth and rounded in outline, the whole landscape having a

"hummocky" appearance. Because of the unevenness of the surface, water collects in the hollows forming ponds, lakes, and marshes [Fig. 74 (*a*)]. East Prussia and the land immediately to the south of the Baltic Sea in Germany is one of the best examples of such scenery, but there are many examples in Great Britain, viz. the Eden lowlands near Appleby and the borders of Cheshire and Shropshire. Morainic land consists of finely-ground soil, containing large numbers of stones. These stones are all rounded (due to ice erosion) and are very varied in composition as a result of their having been collected

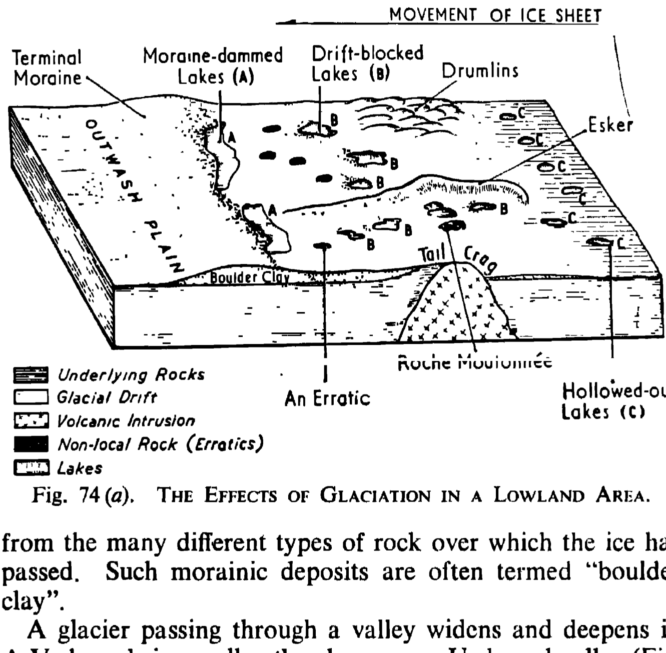


Fig. 74 (*a*). THE EFFECTS OF GLACIATION IN A LOWLAND AREA.

from the many different types of rock over which the ice has passed. Such morainic deposits are often termed "boulder clay".

A glacier passing through a valley widens and deepens it. A V-shaped river valley thus becomes a U-shaped valley (Fig. 75), and the marked change in the slope of the valley sides at B and D denotes the maximum level of the ice.

The larger glaciers of main valleys have greater erosive power than the smaller glaciers of the tributary valleys. The effect of this is, that after the ice has melted, the lower ends of the tributary valleys are higher than the bottom level of the main valley. Such valleys are called "hanging valleys", and

their streams usually drop quickly as waterfalls to the main valley. A series of hanging valleys are to be found in North Wales where the western tributaries of the Conway drop to the main valley, *i.e.* near Trefriw. (See plates facing pages 64 and 128).

Another characteristic feature of valley glaciated topography is the *cirque* (the "*corrie*" of Scotland and the "*cwm*" of Wales). Cirques are roughly semi-circular basins high up in the mountain mass. They have very steep sides and usually contain a small lake or tarn. The erosive action of the ice causes undermining, and the cutting back of the sides. When sufficiently close, and erosion is taking place on two sides of a slope, a very narrow and often jagged ridge results. Such is the "Striding Edge" of Helvellyn (see plate facing page 97) and also the narrow "edges" of Snowdon. The chief features of a glaciated highland region are shown diagrammatically in Figs. 76 (*a*) and (*b*), and by contours in Fig. 12.

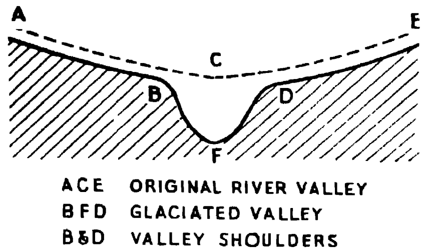


Fig. 75. The Effect of Ice Erosion on a Valley.

Glaciers and ice sheets often carry large boulders of rock on their surface, and these are deposited when the ice melts. In Cheshire the rocks are mainly sands and clays, yet here and there one finds huge rounded blocks of granite which must have come from the Lake District or South Scotland, the nearest points to Cheshire where similar granite exists. These boulders are known as *erratics* (see Plate 14). Rock surfaces over which a glacier has passed are polished and rounded. On their smooth surfaces there are often parallel scratches or *striations* made by the rock material embedded in the underside of the glacier. The direction of the striations indicates direction of the movement of the ice.

On the whole a glaciated region is less rugged than one which has not been glaciated, so that the building of roads and railways is frequently easier. The lowering of slopes, too,

reduces the area unsuitable for cultivation because of steep gradients. On the other hand, ascent from the bottom of steep-sided U-shaped valleys is difficult. This is marked in the steep gradients between the valley farms of Switzerland and the summer pastures of the highlands. Sometimes the soil deposited by glaciers is very fertile, as in East Anglia and much of the wheat lands of North America, but in the morainic heights of North Germany the glacial soils are infertile. The degree of fertility depends largely on the source of origin of the glacial drift.

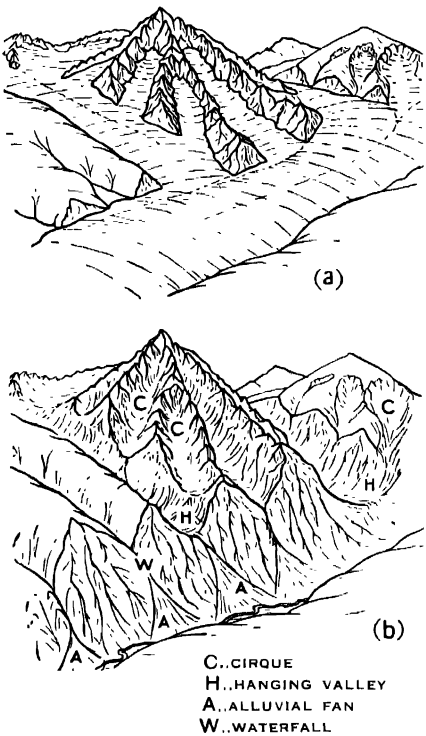


Fig. 76. To Show the Effect of Ice Erosion in a Mountainous Region.

Waterfalls and lakes resulting from glaciation are also of value to man, the former as a source of hydro-electric power, and the latter as reservoirs which help to regulate the flow of streams, or as great waterways, *e.g.* the Great Lakes of North America.

5. The Work of the Wind

The work of the wind as an erosive agent has already been referred to under the section on Weathering (page 105). In addition wind carries a "load" of dust and sand particles which it re-deposits. This aspect of its work is most easily

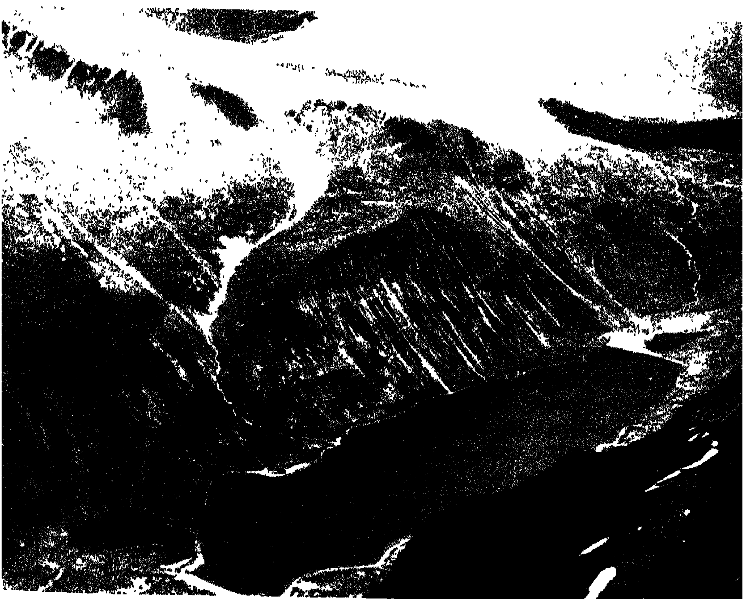


PLATE 13

Above. Lake Maggiore, Switzerland. (*Swiss National Tourist Office.*)

Below: Loch Einich—a typical glaciated region. Note the steep-sided, flat-floored main valley, the hanging tributary valleys, and the cirque (top centre). (*The Bulletin.*)

PLATE 14

Above: A glacial erratic north of Austwick, Yorkshire, a "perched block" of Silurian Grit on Carboniferous Limestone. (*Geological Survey, Crown Copyright Reserved.*)

Below: An esker ridge of gravel resting on chalk at Hildersham, Cambs. (*Geological Survey, Crown Copyright Reserved.*)

PLATE 15

Above: Mt Egmont, a conical volcanic mountain. Note the secondary cone on the slope of the volcano. (*High Commissioner for New Zealand.*)

Below. North Berwick Law—the remains of a lava plug which once filled the vent of a volcano. The softer volcanic debris which surrounded it has been removed by erosion. (*Geological Survey, Crown Copyright Reserved.*)

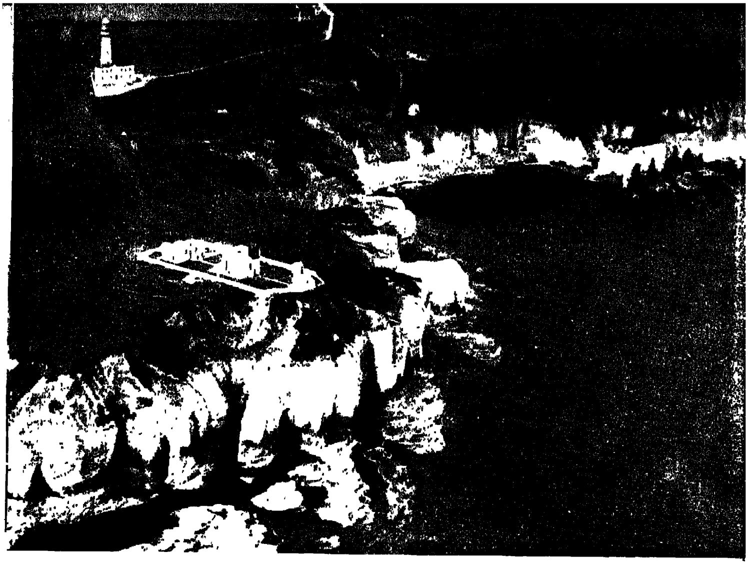


PLATE 16

Above: Flamborough Head. The sea is eroding the chalk headland with the formation of arches and caves. Note deposition in the bay, right centre. (*Aerofilms Ltd.*)

Below: Lulworth Cove. On the extreme left is a chalk ridge, and on the right, fringing the sea, a narrow belt of limestone. The sea, having breached the latter, has eroded the intermediate belt of softer rock into an almost circular cove. (*Judges Ltd.*)

observed in sandy deserts, or the sand dune areas of sea coasts. Mounds and ridges of wind-blown sand are called *dunes*, and their growth is brought about by almost any small obstacle, such as a tuft of grass or a boulder. The sand lodges against such an obstacle, and once started, the dune itself causes a greater accumulation of sand until the dunes may be several hundred feet high as in the Erg region of the Sahara, south

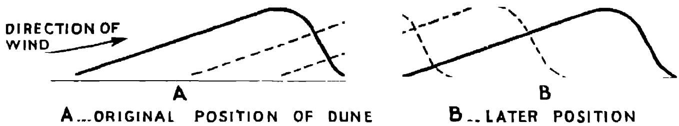


Fig. 77. TO SHOW THE MIGRATION OF SAND DUNES.

of the Atlas Mountains. Sand dunes are not usually stationary. Sand is being constantly blown from the gentle slope of the windward side, and dropped on the steep leeward slope. So the dune moves steadily forward (Fig. 77). As the ends of a dune are lower than the centre they move forward more quickly. This results in the formation of peculiar

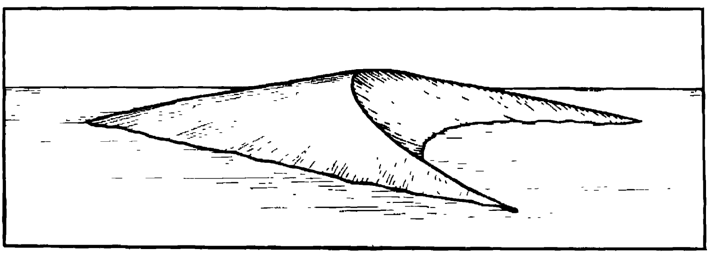


Fig. 78. A BARKHAN.

crescent-shaped dunes known as *barkhans*, such as are found in the Chilean and Persian deserts (Fig. 78).

In some coastal areas the destruction caused by the landward movement of dunes is so great that steps are being taken to "fix" the dunes by planting them with grasses, shrubs, etc. In the south-west of France the extensive sand dunes south of Bordeaux have been planted with pine and fir trees which yield a valuable revenue to the French Government.

Wind-blown sand may cause a great deal of destruction and inconvenience. In many deserts sloping shelters are erected adjacent to the railway track so that the sand will blow over at such an angle that it falls clear of the track on the other side. There are a large number of ancient cities in the deserts of Central Asia which are now buried beneath thick layers of sand. During the space of sixty years in the last century, a church on a stretch of sandy coast in North-East Germany was buried under sand dunes, and the sand was then blown beyond the church exposing its ruins. *Loess* (see page 70) is a re-deposition of wind-blown dust and sand.

The Work of Man

Although the work of man may be considered artificial rather than natural, it is convenient here to draw attention to the great changes man can bring about. Cuttings and embankments, huge quarries, and large mining slag-heaps, are familiar to most of us but there are many other ways in which man has affected land forms. By means of dams, large lakes have been formed, sometimes as much as 100 miles long; vast areas have been reclaimed from the sea, as in the Netherlands; rivers have been deviated and canals built.

Elsewhere the reckless cutting down of forests, and the ploughing up of grasslands in semi-arid areas, has, in some places, greatly accelerated the erosive action of some of the natural agents referred to above (see plate facing page 225). Indeed, soil erosion, whether it be by wind, or by gullying due to running water (see plate facing page 256), is perhaps the world's biggest agricultural problem. It has been estimated that the United States has already lost one-eighth of its top soil, and many other countries are seriously affected. Farmers are being encouraged to reduce the risks of soil erosion by contour ploughing, strip cultivation, the planting of shelter belts of trees, and in other ways. In Great Britain soil erosion is not a serious problem, but in dry summers there are sometimes dust storms of dry powdery soil in the Fen country.

CHAPTER VI

LAKES

Formation of Lakes

Lakes are accumulations of water in hollows on the earth's surface. When they are drained by rivers their waters are fresh, but when they have no outlet they are salty, *e.g.* the Dead Sea, Sea of Aral, etc.

Lakes may owe their origin to (1) The formation of a barrier across a river. (2) Earth movements. (3) Volcanic action. (4) Ice erosion.

BARRIERS ACROSS A RIVER.—Barriers across a river valley hold back the water, which forms a lake. Such barriers may be of various types.

(*a*) Sometimes artificial barriers of concrete and masonry are built across a valley in order to make a lake which can act as a reservoir for the water supply of a large city, *e.g.* Lake Vyrnwy for Liverpool.

(*b*) A glacier may deposit a mass of morainic material across a valley. In this way the lakes of the Lake District and many of the Scottish lakes were formed.

(*c*) A landslip may occur. A lake was formed thus in the Upper Ganges Valley in 1892. Two years later the landslip dam gave way, and disastrous floods occurred downstream.

(*d*) Oxbow lakes are formed from the meanders of rivers (see page 112). The deposition of silt at the two ends of the "oxbow" closes the channel between the main river and its old loop. Many oxbow lakes border the River Murray in Australia, and the lower Mississippi.

(*e*) Sometimes a lava stream may flow across a valley and cause the formation of a lake, *e.g.* Lake Taupo (New Zealand).

(*f*) Sometimes large estuaries are partially filled with silt. In the portions not so filled are large shallow lagoons. Such lagoons are found in deltaic areas. The Norfolk Broads are portions of an old river estuary.

(*g*) When a silt-laden stream enters a lake its speed is checked and a barrier or delta is built across the lake splitting it into two portions. This has happened in the Lake District, where Keswick stands in the alluvial flats between Lakes Bassenthwaite and Derwentwater, and in Switzerland, where Interlaken is situated in the flats between Lakes Thun and Brienz.

(*h*) The action of the sea often causes an accumulation of sand and pebbles which cuts off a lagoon of sea water. The Fleet in Dorset is such a lagoon, cut off from the sea by Chesil Bank, a long pebble beach which joins Portland Island to the mainland. The nehrungs of East Prussia are sand spits which enclose the shallow salt-water lagoons or haffs, viz. Kurische Haff (Fig. 88).

EARTH MOVEMENTS.—Earth movements cause lake formation when subsidence occurs. This is most easily seen in rift valleys (see page 116). Examples of rift valley lakes are the Dead Sea, Lakes Nyasa and Tanganyika in Africa, and Lake Torrens in Australia. These are all long, narrow, and very deep lakes. In Cheshire, the removal of underground beds of salt has caused subsidence resulting in the "meres" of the Weaver Valley. The "folding" of the earth across the line of a river valley may partially block a river and help to form a lake. The study of a good physical map will reveal the connection between mountain building (earth folding) and the formation of Lake Geneva and Lake Constance (Switzerland). Where there are large areas of depressed lowland wide and shallow lakes are formed in the lowest part of the depression, viz. the Sea of Aral in Asiatic Russia, Lake Balaton in Hungary, and Lake Eyre in Australia.

GLACIAL ACTION.— Ice sheets and valley glaciers may scoop out hollows to form "rock basins". Mountain tarns and corrie lakes in North Wales and Scotland have been formed in this way. Water also accumulates in the hollows of unevenly-distributed glacial drift. Such are the lakes of East Prussia, and also those of the Cheshire-Shropshire borders near Ellesmere.

VOLCANIC ACTION.—Subsidence of the lana surface and consequent lake formation may be directly related to volcanic

action. Lough Neagh in Northern Ireland is a shallow lake formed by subsidence of this type. Lakes are often formed by the accumulation of water in the craters of extinct volcanoes, *e.g.* the Laachersee in the Eifel region of Germany.

The Value of Lakes

On the whole, lakes are of great advantage to man. When large systems of lakes occur such as the Great Lakes of North America, they are of inestimable value in opening up the land and providing a cheap and easy means of transport for bulky commodities.

Lakes help to regulate the flow of rivers, preventing the possibility of excessive flooding or of very low water. Thus, rivers containing lakes are of greater value for transport, water supply, and where necessary (*e.g.* the Yangtse-Kiang) for irrigation.

Nearly all large-scale irrigation projects involve the damming back of a river to form a large reservoir or lake, to provide reserves of water for use in dry seasons when the river would otherwise be low. At the same time a good head of water is thus provided for use in hydro-electric plants. New Russian projects on the Volga River involve the formation of several artificial lakes 200 or 300 miles long and up to 20 miles wide.

Very large lakes help to moderate the climate of the neighbouring country. Because of the westerly breezes from Lake Michigan, its eastern shores have their winter temperature raised so that fruit growing is an important occupation, because the danger of frost is lessened. The western shores of the lake are not so important for fruit.

Many large cities depend on lakes for their water supply, *e.g.* Manchester obtains water from Lake Thirlmere in the Lake District. It must also be remembered that lakes add to the beauty of the scenery and so increase the revenue through their attraction for "tourists".

The beds of old lakes are of great importance agriculturally, because of the deep, rich, stoneless soil. The Vale of Pickering in Yorkshire is an old lake bed, and so are the fertile lands in the neighbourhood of Lake Winnipeg in Canada. Lake Winnipeg is the remnant of a much larger lake that once existed there (viz. Lake Agassiz).

CHAPTER VII

VOLCANOES AND VOLCANIC ACTION

Volcanoes and their Eruptions

A volcano is a hole in the earth's crust through which are ejected hot rocks, ashes, lava, steam, mud, and various gases. Such holes occur where there is a thinness or weakness in the earth's crust. The materials which are ejected, falling around the hole or crater, gradually build up a mountain that is roughly conical in shape, and has a crater at the top (Fig. 79). Good examples of such mountains are Fuji Yama in Japan, Vesuvius in Italy, and Chimborazo and Cotopaxi in the

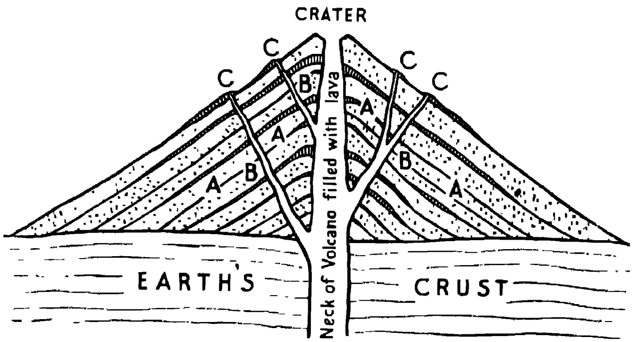


Fig. 79. A Section of a Volcano.—A. Accumulations of volcanic material. B. Secondary lines of lava flow. C. Minor vents or craters.

Andes. Tall, more or less conical, volcanic mountains are composed mainly of ash with a central plug of lava filling the vent. When such volcanoes have been long extinct the soft ash may be removed by erosion, leaving much of the relatively hard lava plug as an isolated volcanic crag (see plate facing page 144). Volcanic mountains consisting mainly of lava tend to be dome-shaped rather than conical.

Volcanoes are said to be *active* when eruptions occur frequently; *dormant* when no eruption has occurred over a long period of years; and *extinct* when no eruption has occurred during historic time. Vesuvius was thought to be

extinct, and Krakatoa, too, had never been known to erupt, but both sprang into activity within historic times.

Most eruptions are preceded by tremors or quakings of the earth, called earthquakes. Then there is usually an outburst of steam and gas. From the rising steam, clouds are formed above the volcano, and heavy rainstorms follow, frequently accompanied by thunder and lightning. After this there is often an explosion, and heated rock is hurled into the air. Lava is forced out of the crater and flows down the mountain sides. The rain, falling on the hot dust ejected by the volcano results in streams of hot mud which are as destructive as the flowing masses of hot lava.

Sometimes volcanic eruptions are of quieter type and there is no explosion. Lava wells up in the crater and flows quietly down the mountain side. Such volcanoes as these occur in Hawaii (Mauna Loa and Mauna Kea), where the lava often flows fifty miles before it cools and hardens.

Stromboli, in the Mediterranean, is an example of a volcano which is continuously and moderately active but from which no lava is ejected. Its constant "glow" has earned for it the name "the lighthouse of the Mediterranean".

Possibly the best known example of a violently explosive eruption was that of Krakatoa in 1883. Krakatoa is a small island in the East Indies. The explosion was so violent that it blew away a large portion of the island, the sea now being 1,000 ft deep where the mountain once stood. Dust was hurled more than 20 miles into the air, the explosion was heard in Australia over 2,000 miles away, and the vibration broke windows in Batavia 100 miles away. Gigantic waves were formed which caused the sea to rise 50 ft on the shores of neighbouring islands. As a result the loss of life was very great, 36,000 people being killed. The dust particles in the atmosphere gave rise to vivid sunsets not only in Asia, but in all parts of the world, during the three following years.

Distribution of Volcanoes

Active volcanoes seem to have a well-defined distribution. Many of them are in mountainous areas, particularly in regions of "new fold" mountains. Many also occur near the sea, or actually in it, rising from submarine ridges, as in the Hawaiian Islands and the West Indies. On the other hand,

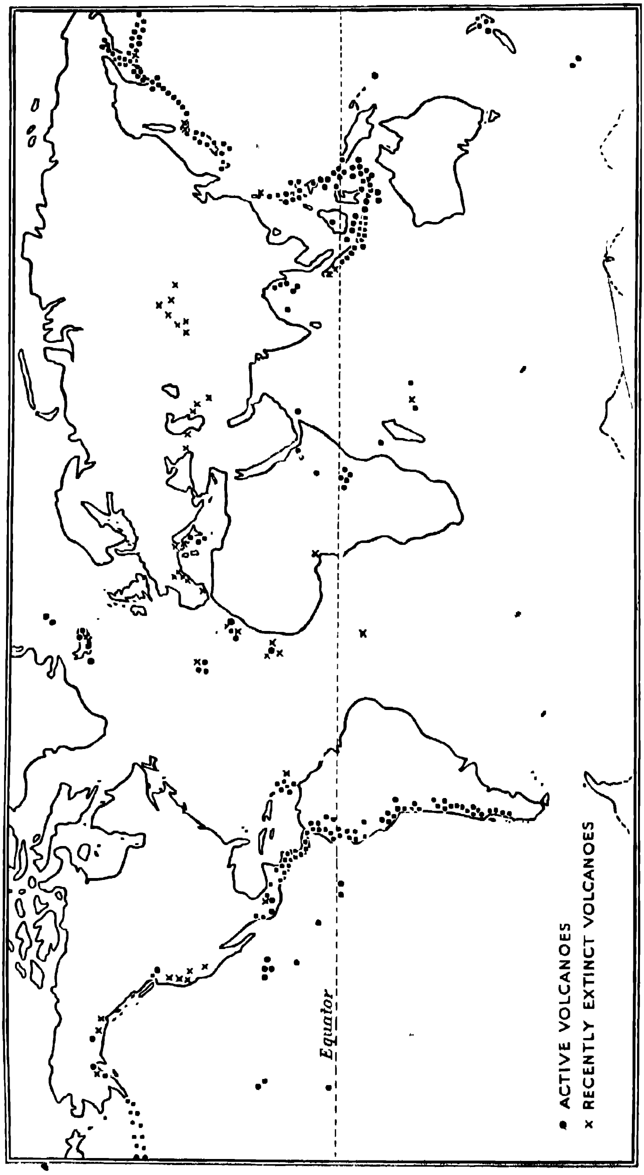


Fig. 80. Map Showing the Distribution of Volcanoes.
Try to locate and name some of the principal peaks in each continent.

some volcanoes are not in highland areas, and some are not near the sea (viz. Kilimanjaro in Africa). The most striking feature of their distribution seems to be the ring of volcanoes which surrounds the Pacific Ocean, extending from Mount Erebus in Antarctica, through the Andes, the Western Cordillera of North America (there is only one active volcano in the United States, viz. Mount Lassen in California), the Aleutian Islands, Kamchatka, Japan, the East Indies, and New Zealand. This girdle of volcanoes is often referred to as the "Fiery Ring of the Pacific". Outside this ring, active volcanoes are found (*a*) in the West Indies; (*b*) in close association with the African rift valley. There are also a large number of extinct cones throughout the central mountains system of Asia (*e.g.* Mount Demavend in Persia). A few volcanoes occur on islands, such as Mount Hekla in Iceland.

Probable Origin of Volcanoes

The belief that volcanoes have their origin in a hot liquid interior of the earth is now considered to be wrong. From observations in mines, etc., it has been found that temperatures increase with depth, and that at a depth of 60 miles the temperatures would be high enough to liquefy rock. But the immense pressure due to the weight of the earth's crust raises the melting point, and it is probable that even at such high temperatures the rocks remain solid. It is now suggested that (1) there is a liquid layer between the solid crust of the earth and a solid and very hot central core; (2) subterranean heat is caused by pressure due to rock folding and to chemical action between the components of the rocks, and this heat helps to produce liquefaction of rock. The lighter lava would tend to rise above the solid rock until it came near to the surface, when lateral pressure might cause it to flow out at the surface in places where the earth's crust was weakest. Fissure eruptions, such as once occurred in Northern Ireland and the North-West Deccan, and the "quiet" type of eruptions which occur in the Hawaiian Islands are possibly due to this cause.

On the other hand, the expansion and explosive forces of steam and other gases seem to be responsible for eruptions of the "Vesuvius" type.

CHAPTER VIII

COASTS AND ISLANDS

Coastal Types

The line where land and sea meet is known as the coastline The *general outline* and *major features* of the coast depend on a number of factors such as (*a*) the structure of the land and the trend of the hills and mountains; and (*b*) whether the land has been raised or depressed. *Minor coastal features*, such as "coves", "stacks", etc., are the result of the (1) nature of the rocks, and (2) the erosive force of the sea.

The Effects of Sea Erosion

The continued roll of the waves along a shore line, and the force of the pebbles carried by the waves during storms, causes the coastline to be worn away, particularly where the rocks are relatively soft or where there are lines of weakness. Such action gives rise to alternations of broad bays and steep cliffs, such as Studland and Swanage Bays in Dorset, and with the alternating headlands known as Ballard Point and Durlston Head (Fig. 81). Here, the belts of rock of unequal resistance run at *right angles* to the coast. On the south coast of England, in Dorset, the work of the sea where the rocks run in belts *parallel* to the coast can be observed. As shown in Fig. 82 the coast is fringed by a belt of limestone (A), behind which are belts of clays (B), and chalk (C). The force of the sea, having breached the limestone wall at

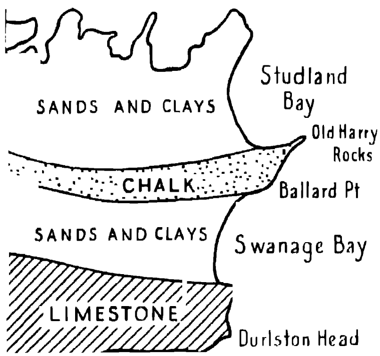


Fig. 81. To Show the Effect of Alternate Belts of Hard and Soft Rock on Coastal Features.

(D), proceeds to the more rapid erosion of the soft clays behind the limestone. This erosion is limited inland by the resistant chalk, so that a roughly oval "cove" is formed, such as Lulworth Cove (see plate facing page 129). Two coves may be extended laterally so that the outer limestone is left standing as small off-shore islands (E). The erosive force of the sea is responsible for such formations as "the Needles", "the Old Man of Hoy", etc.

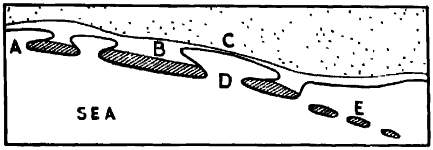


Fig. 82. To Show the Effect on Coastal Erosion of Belts of Rock of Unequal Hardness Parallel to the Coast.

There are natural limits to the formation of coastal openings by sea erosion, for as the waves reach the head of a gulf or bay their speed slackens and the erosive power decreases. Hence there must come a time when an opening due to marine erosion will reach its limit inland. But, at the seaward end of the opening strong waves are still buffeting the cliffs and wearing them away, so that the effect of the sea is to lessen the coastal irregularities rather than to increase them. This can be well seen in the bays near Torquay where there are "bay head" beaches, and also at the heads of many of the openings on the west coasts of Scotland and Ireland.

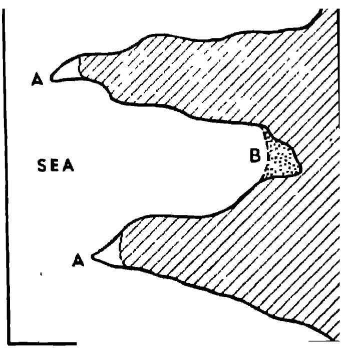


Fig. 83. To Show the Effect of Marine Erosion.

Fig. 83 illustrates marine erosion wearing back the cliffs at A, but at B the sea has little power to erode, and may actually be filling up the head of the opening by the deposition of fine material (resulting from the denudation of the sea cliffs) which has been carried there by the sea currents. In such a way the sea may tend to reduce some of the minor irregularities of the coastline. See plate facing page 129.

Constructive Action of the Sea

The constructive action of the sea includes the formation of sand-spits and sand-bars across the mouths of rivers. Sand-spits and lines of sandy islands are of frequent occurrence in East Prussia (the Haff coastline, Fig. 88), the Frisian islands, on the east and south coasts of the United States (*e.g.* Cape Hatteras), on the south coast of France to the west of the Rhône delta, and on the east coast of South America (*e.g.* Lake Patos).

In England a notable example of the constructive work of the sea is Chesil Bank, a bank of shingle which cuts off a shallow lagoon known as the Fleet, and links Portland Isle with the mainland. The Great Orme at Llandudno was probably joined to the mainland in a similar way.

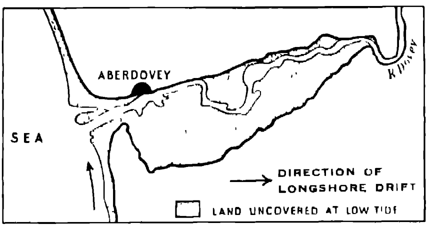


Fig. 84. To Show the Effect of Long-Shore Drift on Coastal Formation.

The estuaries of rivers flowing into Cardigan Bay are characterised by north-pointing sand-spits which partly block the seaward end of the estuary and push the course of the river northward (Fig. 84). This is apparent in the estuaries of the Dovey, Mawddach, and many smaller rivers. The formation of sand-spits is caused by *longshore drift*, which is due to the fact that waves usually approach the shore more or less obliquely and thus tend to carry sand and shingle parallel to the shore. In Cardigan Bay the longshore drift is northwards, but on the east coast where it is southward, there are similar, but south-trending, sand-spits, *e.g.* at the mouths of the Yare, Alde, Stour, etc.

Major Coastal Features

Such minor coastal features as have already been referred to are only apparent in maps of great detail, such as the "one-inch" Ordnance Survey Maps of Great Britain. On atlas maps only the major characteristics of a coastline are shown, and

these generally are the result of factors other than sea erosion, though the latter plays its part in producing the detailed sculpturing of every coastal type.

The following are some of the principal coastal types:—

(1) The Fiord coastline.
(2) The Ria coastline.
(3) The Dalmatian coastline.
(4) The Haff coastline.

(1) THE FIORD COASTLINE (Fig. 85).—On the coast of Norway or Western Scotland are a large number of long narrow

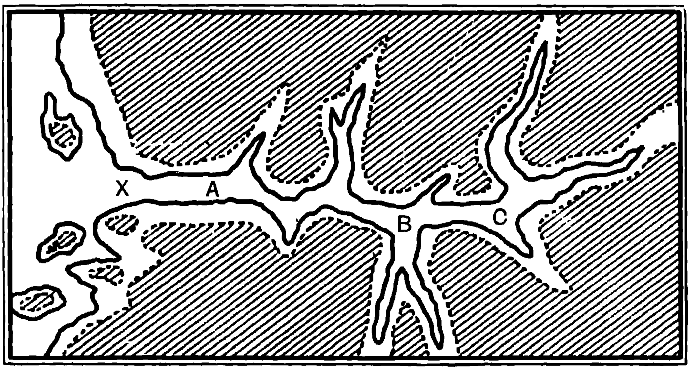


Fig. 85. A FIORD.—Shows how the highland comes close to the fiord side. X is shallower than A, B, C.

inlets with very steep sides. These are called *fiords*. They are usually shallower at their seaward end than they are at their landward end. These inlets have been formed by the gradual sinking of the land so that the sea has covered the lower or valley areas. Thus they are a type of drowned valley. The excessive steepness of the sides may be due to erosion by ice, which produces a steep-sided U-shaped valley, or to faulting. (See plate facing page 160.)

Such openings form good sheltered harbours, but since the fiord sides are steep and communication inland is difficult, and since the land behind the coast is unproductive, fiord coasts such as those of Western Scotland have few important

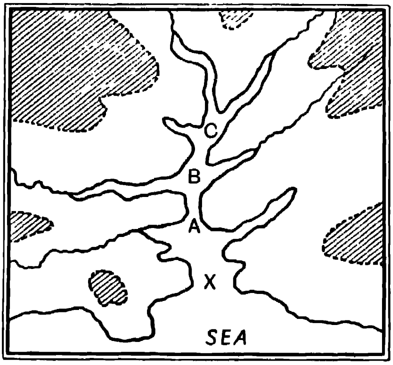


Fig. 86. A RIA.—Note the highland well back from the coast and the relation of tributary valleys to the shape of the sea coast. X is deeper than A, B, C.

ports. The length of the Sogne Fiord is equal to the distance from London to Bristol.

(2) THE RIA COASTLINE (Fig. 86).—Rias are also drowned valleys, but since they have not been previously glaciated, the sides are more gently sloping and access inland is easier. The openings in South-West Ireland, such as Bantry Bay, and in Cornwall, such as Plymouth Sound and Falmouth Harbour, are good examples of rias. The tributary valleys have been drowned, as well as the main valley, giving these openings a complicated "branching" shape.

(3) THE DALMATIAN COASTLINE (Fig. 87).—The eastern coast of the Adriatic Sea offers a good example of the way in which the nature of the land influences the type of coastline. Here the mountain chains run in a N.W.-S.E. direction, parallel to the shore. The area has been "drowned", so that the narrow entrances open out into broad inlets parallel to the main trend of the coastline. The islands off-shore are really the submerged tops of mountain ranges. These islands are hilly, long and narrow, and parallel to the shore.

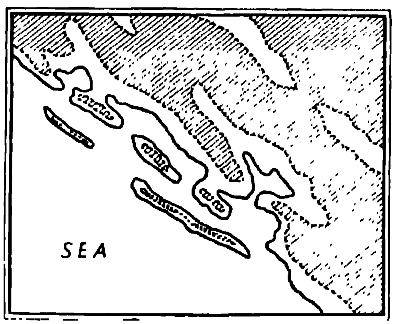


Fig. 87. DALMATIAN TYPE OF COAST. Note the shape of openings and islands and the relation of the highland to the coast.

(4) THE HAFF COASTLINE (Fig. 88).—Some coastlines are low and unindented. The coastline of East Prussia

consists of a series of narrow strips of land running roughly parallel to the coast. These strips are really large sand dunes, and they cut off shallow lagoons called, in Germany, "haffs". In time these lagoons are completely filled by wind-blown sand and by silt deposited by the rivers flowing in from the land. This results in a coast type like that south of the Garonne in France, or similar to the short strip of the Somersetshire coast lying south of Weston-super-Mare. On some coasts, such as those of the north of Holland, a line of long and narrow, low sandy islands runs parallel to the shore. These coastlines offer no good harbourage, but are usually backed by extensive plains which are productive and do not hinder communication.

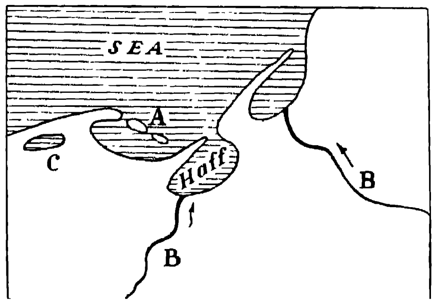


Fig. 88. Sand Dune Coast.—A. Sandy Islands. B. Rivers bringing down silt. C. Lagoon (remnant of an old haff).

Islands

Islands are often classified as (*a*) Continental; (*b*) Oceanic.

Continental Islands.—This is the name applied to those islands which:—

(1) Lie near to the shores of a continent.

(2) Are a continuation of the same rock and structure as the continental mainland.

(3) Are usually separated from the mainland mass by shallow seas (*i.e.* under 600 ft in depth).

Most continental islands rise from the bordering continental shelf, *e.g.* the British Isles, and Newfoundland. Some, however, while rising from deeper water, may have definite structural links with the continent, *e.g.* the East Indies are a continuation of the Asiatic "fold" mountain system, as is Sicily of the European "folds". It can generally be assumed that continental islands have, at some stage in their physical history, been joined to the adjacent mainland. Madagascar is an interesting example of an island which has been separated from the mainland for a very long period, for

although it is divided from Africa by the wide and deep (nearly two miles) Mozambique Straits, a study of its rock formation and its animal life suggest its former connection with Africa.

OCEANIC ISLANDS.—These, on the other hand, lie in the open ocean at great distances from the continents. Their structure bears no relation to the nearest shores, and they rise from the ocean depths. They may be the tops of submarine ridges (see page 85). Thus Ascension and Tristan da Cunha rise from the Central Atlantic Ridge. Other oceanic islands may be of volcanic formation, viz. St Helena and Teneriffe.

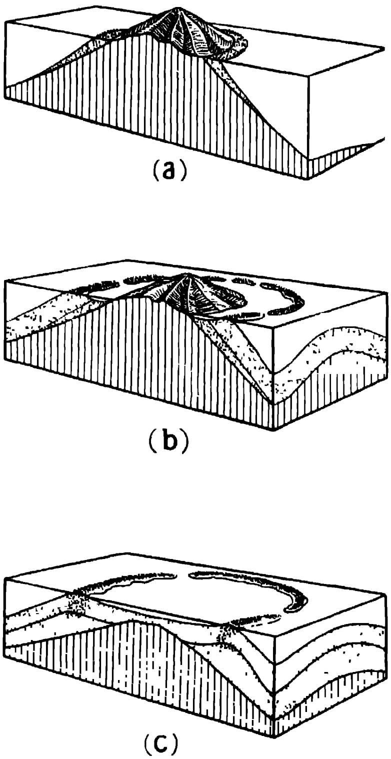


Fig. 89. CORAL ISLANDS.—(*a*) A fringing reef. (*b*) A barrier reef. (*c*) A large atoll.

Yet another group of oceanic islands are those of coral formation. Coral is a limestone deposit formed by the accumulation of the "hard parts" or skeletons of the coral polyps — minute sea organisms.

The reef-building coral is limited in its distribution, for it can only flourish under the following circumstances:—

(1) The temperature of the sea must be about 70° F. Such a sea temperature is rarely found beyond 30° N. and 30° S. Within these limits, ocean temperatures are higher on the east of continents than on the west (see page 92), hence coral islands are usually found off *the eastern coasts of continents within the Tropics.*

(2) As temperature decreases with depth, the coral polyps cannot live below a depth of about 150 ft. The coral therefore lives in shallow inshore water.

(3) The coral polyps cannot flourish in fresh water (*i.e.* near the mouths of rivers) because such water does not contain the necessary salts.

(4) Coral does not live in silt-laden water such as is brought down to the sea by rivers.

Low, circular coral islands each with a central lagoon of shallow water are known as "atolls". There are many theories to explain the formation of such islands. That of Charles Darwin is the one most generally accepted. His theory stated that the coral began to build a reef around an island [Fig. 89 (*a*)]. Such a reef, contiguous to the shore, is known as a "fringing reef".

He assumed that the island then sank, and that the coral continued building upwards [Fig. 89 (*b*)] so that the coral reef is separated from the island by a "lagoon" of shallow water. At this stage the reef is known as a "barrier reef".

Further subsidence causes the island to "disappear", but as the coral building still proceeds a circular ring of coral is left, known as an "atoll" [Fig. 89 (*c*)]. Such islands only rise a few feet above sea-level. In course of time the coral limestone is weathered into soil, then seeds, possibly carried by birds, germinate and gradually permanent vegetation is established. The coconut palm is the most typical plant of such islands.

Darwin's explanation of the formation of atolls is not accepted by all scientists, and his theory certainly does not explain the occurrence of atolls in places where subsidence has not taken place. Here the coral may have built upwards from slightly submerged mountain tops or plateaux.

CHAPTER IX

CLIMATIC FACTORS—I. TEMPERATURE

Introductory

"Climate" should not be confused with "weather". The *climate* of a place may be defined as the *average* conditions of temperature, rainfall, humidity, winds, sunshine, and cloudiness typical of that place.

The state of the temperature, rainfall, etc., at a given time, and its deviations from the average conditions constitute the *weather* of a place. Variations from the average conditions, *i.e.* change in the weather, are most common in temperate latitudes.

The study of climate should include consideration of (1) the average temperature and (2) the annual range of temperature; (3) the total annual rainfall; (4) the seasonal distribution of the rainfall; (5) the prevalent winds; and (6) the amount of sunshine and cloudiness.

Temperature is recorded by thermometers. The Fahrenheit thermometer (freezing point 32° and boiling point 212°) is most generally used for weather observations, and the Centigrade (freezing point 0° and boiling point 100°) for other scientific purposes.

The Recording of Temperatures

The required thermometers are placed in a special screen known as a Stevenson screen, so constructed as to allow free passage of the air around the thermometers, but protecting them from the direct rays of the sun. In this way the shade temperature of the air is obtained.

A maximum thermometer records the highest temperature for the day, whilst a minimum thermometer records the lowest temperature. The mean or average of these two readings is the mean temperature for that particular day. This process is repeated for every day of the year, and the average of the daily readings is calculated. The result thus obtained is the mean temperature for that particular year, which may, perhaps, have been abnormally hot or cold. Therefore, these annual results

are collected for a period of thirty to forty years, and the average found. This final result is the Mean Annual Temperature of a given place. It is obvious that the collection of such data has involved an immense amount of work, and during the last half-century, in England, the records have been obtained largely by voluntary enthusiasts.

The Mean July Temperature is obtained by taking the daily maximum and minimum temperatures for the month of July and finding the average. Then similar data for the months of July in preceding years are collected and the average found. The Mean January Temperature is obtained in a similar way.

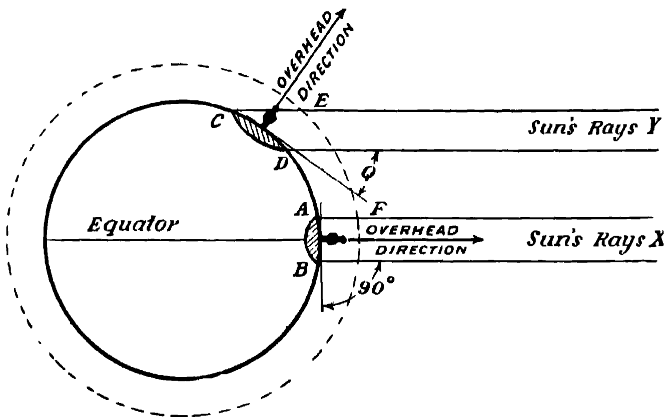


Fig. 90. The Dotted Line Denotes the Belt of Atmosphere Around the Earth.

Factors Affecting Temperature

The temperature of a place depends on the following factors: (*a*) Latitude; (*b*) Altitude; (*c*) Distance from the sea; (*d*) Prevailing winds; (*e*) Ocean currents; (*f*) Clouds and rainfall; (*g*) Slope of the land.

(*a*) Latitude.—On an average, temperature decreases from the equator to the poles. This is because as we go nearer the poles the sun's rays fall more obliquely on the earth's surface. Study Fig. 90 carefully. Suppose X and Y are two bundles of the sun's rays of equal thickness, *i.e.* with the same heating power, striking the earth in March or September. The rays X

meet the earth at the equator at right angles, but the rays Y meet the earth at CD at an angle much less than a right angle (angle Q).

Now the bundle of rays X, has to heat the shaded area AB, while the bundle of rays Y, has to heat the shaded area CD. But AB is much smaller than CD, and since the heat applied is the same in both cases, it follows that the area AB near the equator must be hotter than the area CD nearer the poles.

Again, the bundle of rays Y, because of its obliquity, has a longer passage through the atmosphere than the rays X (EC is longer than AF). Thus, more of the energy of the sun's rays will be absorbed by particles of moisture, dust, etc., so that when the sun's rays Y ultimately reach the earth they will have been deprived of more of their heating power than the bundle of rays X. (Note that these same principles may be applied to the heating power of the sun at midday, sunrise, and sunset. At midday the rays of the sun strike the earth less obliquely than in the morning or evening. Also when the sun is low in the sky its rays have to pass through the atmosphere for a greater distance in the evening than at midday.)

(*b*) ALTITUDE.—Temperature usually decreases as one goes upward from the earth, roughly at the rate of 1° F. for every 300 ft. For instance, a mountain 3,600 ft high would be 12° F. colder at the top than at the bottom. Snow remains unmelted on mountain tops when there is no snow on the plains. It may be thought that the mountain top, being nearer to the sun, should be warmer, but the sun's rays do not heat the air directly. They heat the earth, and the warmed earth in turn heats the atmosphere.

The heat gained by the earth is thus radiated to the atmosphere, dispersing more rapidly the lower the pressure. As pressure falls with altitude any heat gained by the mountain surface is quickly lost, so the atmosphere in contact with it remains cold.

At times an "inversion of temperature" occurs. Temperature inversions are common in winter. The ground rapidly loses its heat once the sun is low, and begins to cool down the layer of air in contact with it, and by sunrise air to a height of perhaps several hundreds of feet may be colder than that above it. Under these conditions temperature *increases* with height up to certain limits, and since the colder, heavier, air is at the bottom, convection currents do not form. Smoke therefore does not rise but spreads out horizontally and keeps close to the surface.

(*c*) DISTANCE FROM THE SEA.—During the summer the sun, shining on land and sea, warms both, but the sea does not become as warm as the land. Hence, if a place is near the sea, a wind from the sea will bring cool air in summer and lower the temperature, while a place situated inland away from the sea will be hotter.

In winter the land loses the heat it has gained during the summer much more quickly than the sea, so that in winter the sea is warmer than the land. Therefore, in winter, sea breezes will carry warm air to the land and raise the temperature of places near the coast, while places inland will be colder.

Valentia, in South-West Ireland, has a summer temperature of 59° F. and a winter temperature of 44° F., while Tomsk, in Central Siberia, and nearly in the same latitude as Valentia, has a summer temperature of 66° F. and a winter temperature of -3° F. (*i.e.* 35° below freezing point). Valentia has a range of 15° F., while Tomsk has a range of 69° F. We refer to the climate of Valentia as *Insular*, *Maritime*, or *Oceanic*, while we speak of the climate of Tomsk as *Continental* or *Extreme*.

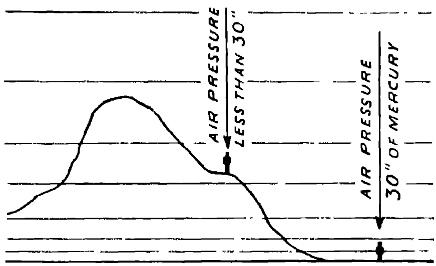


Fig. 91. THE ATMOSPHERE BECOMES LESS DENSE AS ONE ASCENDS.

Maritime climates are found in islands, and in coastal regions where the prevailing wind blows from the sea. (These climates also have heavy rainfall throughout the year.) Continental climates are found in temperate latitudes in areas remote from the sea, or even in coastal regions where the winds blow from the land. (These areas have less rainfall than maritime areas, and the rain falls mainly in the summer.)

(*d*) PREVAILING WINDS.—The effect of prevailing winds in determining the temperature of a place depends on the nature of the region from which the wind blows. A wind from the sea lowers the summer and raises the winter temperature, *e.g.* the westerly winds of the British Isles. A wind from the land

lowers the winter temperature and raises the summer temperature, *e.g.* Manchukuo has very cold winters because the prevailing winter wind blows from Central Asia.

(*e*) OCEAN CURRENTS.—Ocean currents modify the temperature of winds blowing over them, *i.e.* a wind which has passed over a warm current will have its temperature raised, and one which passes over a cold current will have its temperature lowered. The general statement that warm currents raise, and cold currents lower, the temperatures of neighbouring lands is not entirely correct. The power of the currents to affect the temperature depends very largely on the direction of the prevailing winds. Off the east coast of the United States, for instance, there is a warm current, the Gulf Stream. In summer, when the winds are mostly on-shore, the effect of the current is to raise the temperature (and the rainfall), but in winter, when the winds mostly blow off-shore, the current has little effect. In Labrador the cold current has little effect in winter, when the winds are mainly off-shore, but it has a chilling effect on the summers (and reduces the rainfall) when the winds are mainly on-shore. These general principles can be applied in relation to the effects of any ocean currents on the climates of their neighbouring shore lands.

(*f*) CLOUDS AND RAINFALL.—Heavy rainfall, accompanied by dense cloud, obscures the sun and thus reduces the temperature. On the other hand, in regions of little cloud and free radiation, such as desert areas, very high day temperatures are recorded. Since there is no layer of cloud ("cloud blanket") to prevent the free radiation of heat, night temperatures fall rapidly, and such districts have a very high diurnal (daily) range of temperature.

(*g*) SLOPE OF THE LAND.—South-facing slopes are warmer than north-facing slopes, partly because the northern slopes are exposed to cold north winds while southern slopes are sheltered from them, and partly because the rays of the sun strike south-facing slopes at a steeper angle than they do the northern slopes. In Fig. 92, AB, a smaller area, receives the same heating power as does CD, a larger area, and this is clearly due to the angle between the slope of the surface of the earth and the rays of the sun.

Isotherm Maps

As we have seen above, the actual temperature recorded at a given place depends a lot on its height above sea-level. If we wish to examine the effects due to other causes we must first eliminate the height effect. To do this we "reduce to sea-level" by adding on to the observed temperature 1° F. for each 300 ft of altitude. If we now plot the results on a map and draw lines joining all places with the same temperature we obtain lines called *isotherms*.

Factors Affecting Range of Temperature

The difference between the mean temperature of the hottest month and the mean temperature of the coldest month is

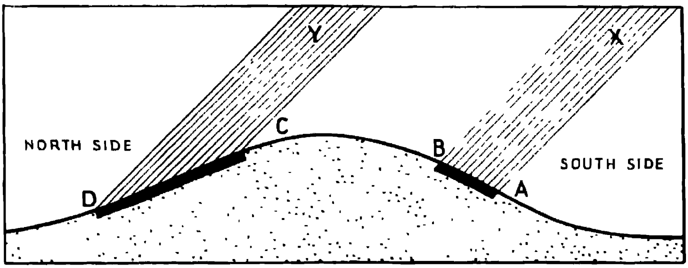


FIG. 92. TO SHOW WHY SLOPES FACING THE SUN ARE HOTTEST.

called the Mean Annual Range of Temperature. For instance, the Mean July Temperature of London is 64° F., and the Mean January Temperature is 38° F. Therefore the Mean Annual Range of Temperature for London is 64° − 38° = 26° F.

The difference between the maximum and minimum temperatures of any one day is termed the Diurnal Range of Temperature. The hottest part of the day is after midday, usually between 1 p.m. and 2 p.m., and the coldest part of the day is generally about half an hour before sunrise.

The principal factors affecting the mean annual range of temperature are: (1) Latitude; (2) Distance from the sea; (3) Prevailing winds; (4) Ocean currents; (5) Cloudiness.

(1) LATITUDE.—In general the annual range of temperature increases from the equator to the poles. This is because the

difference between the amount of heat received from the sun during its periods of maximum and minimum elevation is least at the equator and greatest at the poles. In other words, it is always hot at the equator where the sun is always high in the heavens, so that there is little difference between the mean temperature of the hottest and coldest months. At the poles the sun shines for six months, and for almost six months it is below the horizon, thus there is a great difference in the amount of heat received during summer and winter, and consequently there should be a large range of temperature.

Other factors, however, come into play, so that the greatest ranges of temperature are not found at the poles but in the cool temperate regions about latitude 60° N.

Because the polar regions are snow-covered, much of the energy of the sun's rays is spent in melting part of the surface snow, and thus the permanent snow-covering keeps the summer temperatures low, so that the range of temperature is not as great as would be expected.

(2) DISTANCE FROM THE SEA.—Land becomes hot more quickly than the sea, and also cools more quickly. Places near to the sea are cooler in summer and warmer in winter. The annual range of temperature is therefore decreased. In general, it may be said that islands have a smaller range of temperature than the interior of continents *in the same latitude*. The smallest range in temperature in the British Isles, in temperate latitudes, is, however, greater than the greatest range of temperature in the Amazon Basin, in equatorial latitudes.

Coastal areas also have a smaller range than the interior of land masses. Thorshaven, in the Faroe Islands, has an annual range of 14° F., while Yakutsk, in the same latitude in Central Asia, has a range of 110° F. It is interesting to note how the range of temperature increases from the sea inland along a given line of latitude.

The following places are almost exactly in the same latitude north of the equator, but each in turn is further from the Atlantic than the preceding one. As the distance from the ocean increases, the summer temperatures increase, and the winter temperatures decrease, so that the range of temperature gradually increases.

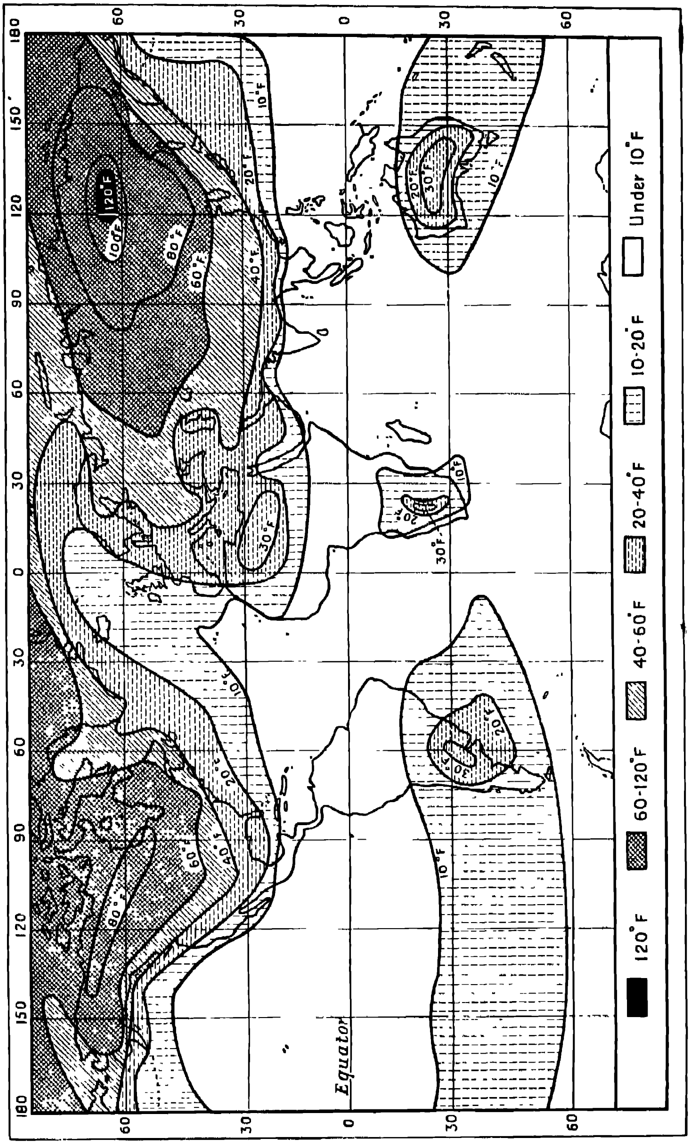


Fig. 93. MEAN ANNUAL RANGE OF TEMPERATURE.

	Summer	Winter	Range
Valentia . .	59° F.	44° F	15° F.
Cambridge .	62° F.	37° F.	25° F.
Hanover	63° F.	33° F.	30° F.
Berlin .. .	65° F.	31° F.	34° F.
Warsaw .	66° F.	26° F.	40° F.
Orenburg	71° F.	3° F.	68° F.

Note that the summer temperatures increase less rapidly than the winter temperatures decrease, showing that the sea has a greater moderating effect in winter than in summer.

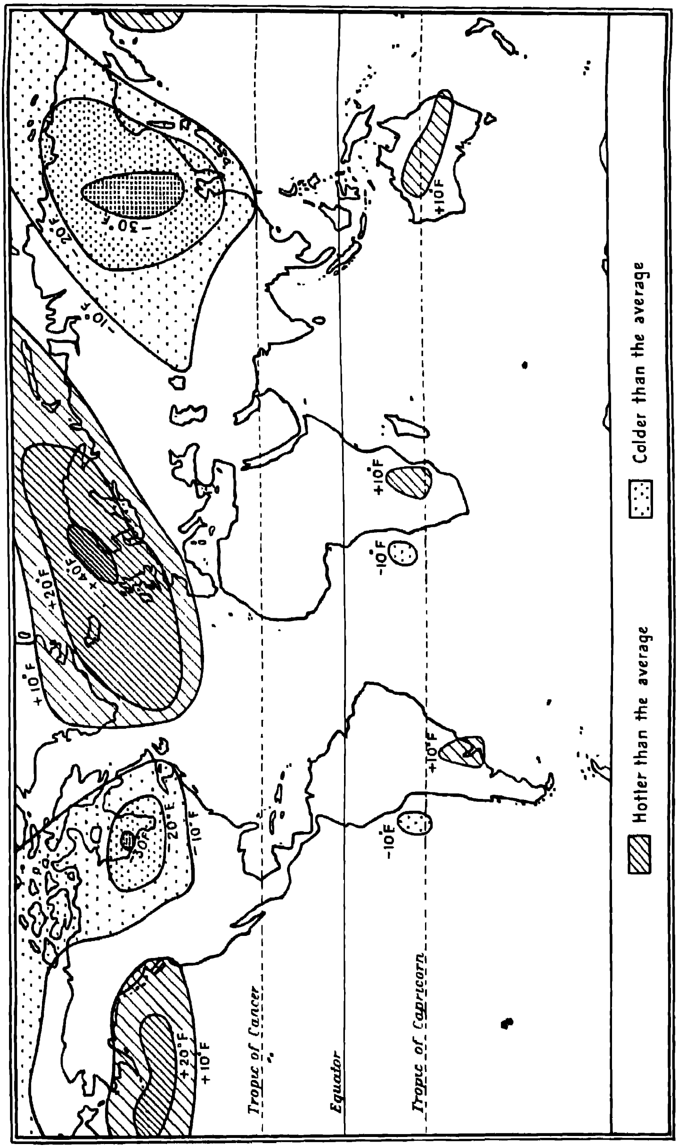
(3) Other Factors Affecting Range of Temperature.—Prevailing winds, ocean currents, and cloudiness affect range of temperature in so far as they raise or lower the temperatures of any given place. British Columbia, which has prevailing winds from the sea at all seasons, has a lower range than Labrador, which has winds mainly from the sea in summer and mainly from the cold land in winter.

To sum up, it will be seen on the map (Fig. 93) that:—

(1) *Low ranges* of temperature occur (*a*) in equatorial latitudes (whether near the sea or inland); (*b*) on islands or coastal areas in other latitudes.

(2) *Large ranges* occur in the centre of land masses in the temperate zone. As, however, the land masses of the temperate zone of the Southern Hemisphere are narrow, no places are far removed from sea influence, and the largest range of the Southern Hemisphere is 32° F. in Western Argentina (San Juan). Contrast this with the range of temperature at Verkhoyansk in Siberia (60° F. to - 60° F., *i.e.* a range of 120° F.). Extensive areas of large annual range are confined to the Northern Hemisphere, *i.e.* Central Eurasia and Central North America.

(3) In the temperate zone the east side of a continent has a larger range than the west side of the continent, due to the greater severity of the eastern winters. The river Pei-Ho, at



F 94. TO SHOW AREAS HOTTER AND COLDER THAN THE AVERAGE FOR THE LATITUDE IN JANUARY.

Peking, freezes every winter, but the River Tagus at Lisbon, even though it is in the same latitude, does not freeze.

Regions with Temperatures Higher or Lower than the Average for the Latitude

Broadly speaking, temperature decreases polewards, but the rate of decrease, owing to the influence of land and sea distribution, is not constant. Therefore, certain areas have summer or winter temperatures which are considerably warmer or colder than the average temperatures of the latitudes in which they lie. In the Southern Hemisphere where the ocean predominates, the deviations from the normal both in January and July are less pronounced.

(i) JANUARY (Fig. 94).—(*a*) In January the *Northern Hemisphere* experiences winter conditions, so that the land masses of the temperate zone will be colder than the oceans. There are two areas, which, owing to oceanic warmth, have temperatures considerably above the normal. These lie in the east of the North Pacific Ocean and in the east of the North Atlantic Ocean. The latter, because of its very high winter temperatures for the latitude, is often referred to as the "Gulf of Winter Warmth" (note the shape of the 32° isotherm for January).

In contrast, the central and eastern portions of North America and Eurasia are regions of excessive cold, because they are removed from the warming oceanic influences of the westerly winds.

The easterly position of the warm and cold areas over both oceans and continents is due (*a*) partly to the westerly winds which lose their moderating influences as they blow eastward over the land, and (*b*) partly to the occurrence of warm and cold currents (see Fig. 60). In temperate latitudes cold currents lower the temperature on the west of the ocean, and warm currents raise the temperature on the east of the ocean (cf. the coasts of Eastern Canada and North-West Europe).

(*b*) In January the *Southern Hemisphere* is experiencing summer conditions so that the land masses are warmer than the ocean. Areas of excessive warmth occur over the three southern continents, but they are not so extensive as those of the Northern Hemisphere, and differ much less from the

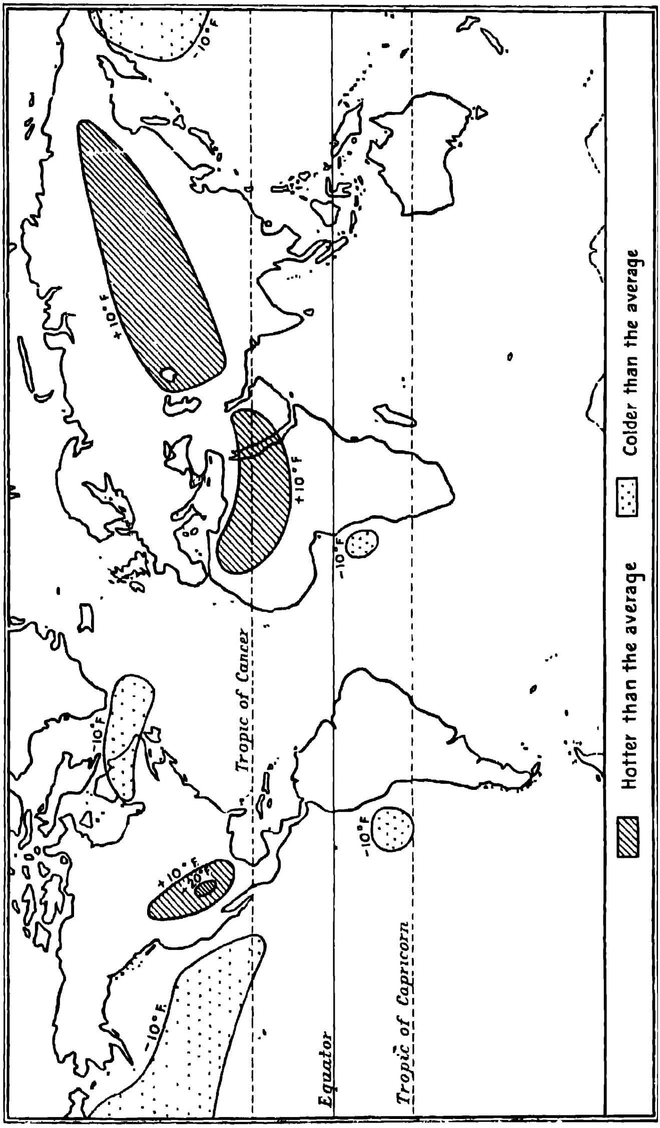


FIG. 95. TO SHOW THE REGIONS HOTTER AND COLDER THAN THE AVERAGE FOR THE LATITUDE IN JULY.

average temperature for the latitude. This is because oceanic influences are strong in the Southern Hemisphere.

Small areas of relative coldness occur to the west of both South America and Africa in the regions of cold north-flowing currents (Fig. 60), but there is no corresponding area to the west of Australia. This is because warm equatorial currents flowing westward to the north of Australia, minimise the coldness of the Westralian Current.

(ii) JULY (Fig. 95).—(*a*) In July in the *Northern Hemisphere* summer conditions prevail, so that the land masses are hotter than the oceans.

Areas of exceptional warmth are to be found over Central Asia, North Africa, and the west of U.S.A. Cool regions occur over the North Pacific and the North-West Atlantic. The effect of the cold currents of the temperate zone can be again observed.

(*b*) In July it is winter in the *Southern Hemisphere*, and it would naturally be expected that there would be cold areas over the land masses and relatively warm areas over the oceans. This, however, does not occur, because the southern oceans are so extensive and the land masses relatively small. Therefore the continents do not experience conditions of winter cold comparable to those of the winters of the north temperate zone. Areas of abnormal cold are absent from the land masses, but occur over the ocean to the west of South America and Africa in the regions of the cold currents as in January. As in January also, there is no corresponding cold area to the west of Australia.

CHAPTER X

CLIMATIC FACTORS—II. RAINFALL

Measurement of Rainfall

Rainfall is measured in inches. "One inch of rain" is the amount of rain it would take to cover a uniformly flat surface with water to the depth of 1 in., provided that none evaporated, drained away, or sank into the ground. A snowfall 1 ft in depth is roughly equivalent to 1 in. of rain.

An inch of rain represents a very heavy fall of rain, and it is exceptional in England for places to record an inch of rain in one day, though in summer thunderstorms such results may be recorded.

Rainfall is measured by means of a rain gauge (Fig. 96). This consists of a round vessel placed in an open position, *i.e.* not sheltered by walls, houses, etc. The top of the vessel is funnel-shaped so that the rain is directed into a bottle. Each morning the bottle is removed and the contents emptied into a special measuring-jar, so marked that it reads as "one inch" the amount of rain it would take to cover the area of the top of the rain gauge to the depth of 1 in. Because the measuring-jar is elongated it is possible to read the rainfall correctly to 0·01 in.

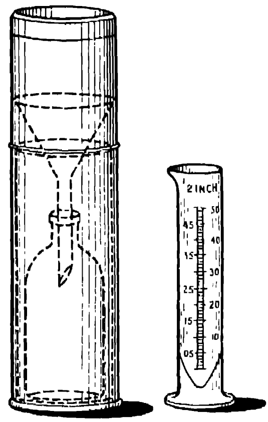


Fig. 96. RAIN GAUGE (SNOWDON PATTERN) AND MEASURING GLASS.

The daily records are added for the year, and the result is the total rainfall for one particular year. As that year may have been exceptionally wet or dry the totals for 30 to 40 years are taken and the average obtained. This final result is the Mean Annual Rainfall of a given place. As in the case of temperature and pressure, the results are inserted on maps, and lines are drawn joining all places with the same rainfall. Such lines are called *Isohyets*.

Causes of Rainfall

Actually there is one general cause of rainfall, viz. the cooling of air saturated with water vapour. The cooling process, however, may be due to various causes. Air which holds as much moisture as possible is said to be saturated. When this occurs and the air holds 100 per cent. of the moisture it is capable of holding, the *relative humidity* of the air is 100. If the air at a given temperature holds only 50 per cent. of the water vapour it is capable of carrying, then the relative humidity is 50. Warm air, however, can hold more moisture than cold air, so that the actual amount of moisture required to saturate air at a low temperature (*i.e.* to give a relative humidity of 100) may only be three-quarters of the amount required to saturate an equal volume of air at a higher temperature. Thus a given amount of moisture may result in a relative humidity of 100 at one temperature, but only produce a relative humidity of 75 at a higher temperature. When reference is made to a damp or dry atmosphere, it is the relative humidity and not the actual amount of moisture in the air that must be considered. For instance, the warmer air mentioned above with a relative humidity of 75 would dry clothes on washing day, but the cooler air with a relative humidity of 100 would not, because it is already saturated. (And yet, it must be noted, in these two examples it has been assumed that the actual amount of water vapour present is the same.) Not only is warm air capable of holding more moisture than cold air (a cubic foot of dry air in the Sahara may contain more moisture than a similar volume of damp air in this country), but the cooling of saturated air from 90° F. to 80° F. (ten degrees) produces a much heavier rainfall than the cooling of saturated air from 50° F. to 40° F. (also ten degrees).

This can be understood by reference to Fig. 97, which shows the curve of saturation of air by water vapour. The horizontal axis shows temperature, and the vertical axis the amount of moisture it takes to saturate air at the given temperature. The amounts of rainfall deposited by cooling from 90° to 80° and from 50° to 40° correspond to the thick vertical lines AB and CD. This principle is important because it helps to explain the torrential downpours of inter-tropical lands, and why it is that the precipitation (rainfall, snow, and hail) of polar areas

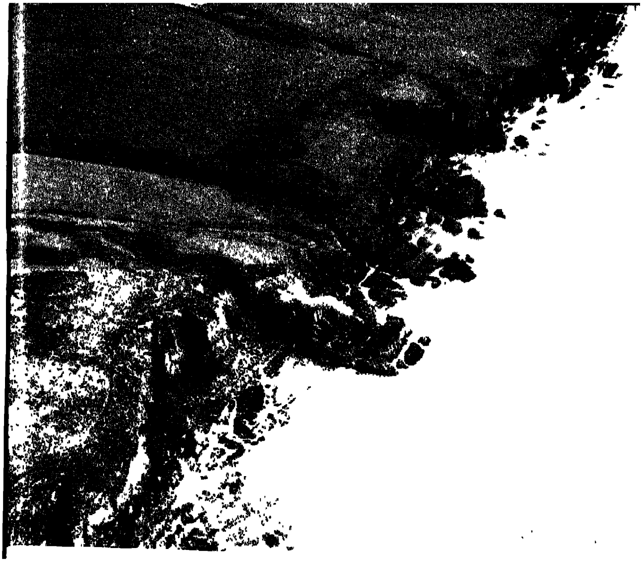


PLATE 17

Above: Cliffs near Kinsale, Eire. (*Aerofilms Ltd.*)

Below: George Sound, New Zealand—a fiord. (*High Commissioner for New Zealand.*)

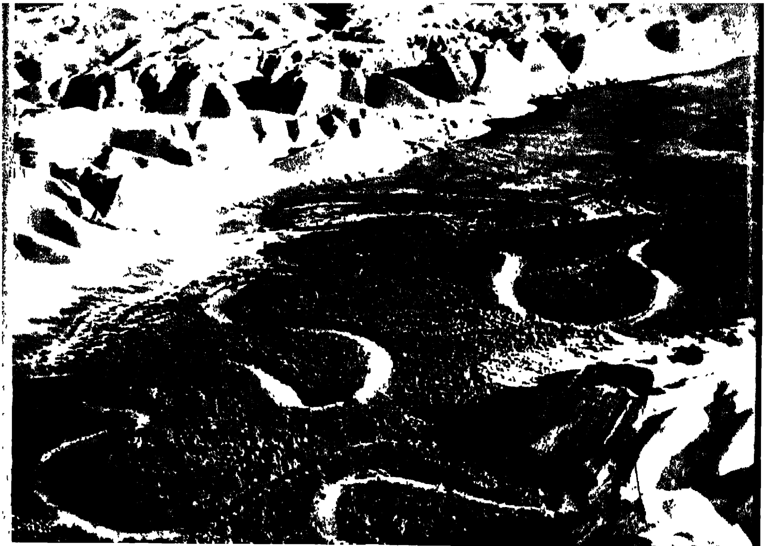


PLATE 18

Above: The Jordan Rift-Valley, showing river meanders. (*Exclusive News Agency.*)

Below: Flowing deep-bore artesian well, east of Darling River, New South Wales. (*Australian News and Information Bureau.*)

and high mountains is low, for winds which contain little moisture to begin with cannot produce heavy rainfall however much they may be cooled.

Clouds consist of very small droplets of condensed water vapour (except the delicate high *cirrus* clouds which are composed of ice crystals). When clouds are many thousands of feet thick these small droplets run together (for reasons not yet fully understood) to form larger drops which can no longer remain suspended in the air but fall as rain.

The cooling of air resulting in precipitation of rain, snow, or hail may be due to (*a*) relief; (*b*) convection; (*c*) depressions (sometimes called "cyclones", a term better reserved for certain tropical storms. The term "cyclonic", however, is commonly used to describe the type of weather associated with depressions).

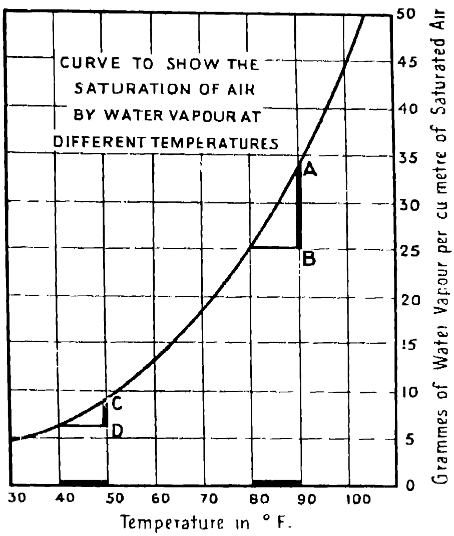


Fig. 97.

(*a*) RELIEF.—Temperature decreases as one ascends. If, then, a wind blowing from the sea is saturated with water vapour, and comes to a high mountain range, it is forced to rise and so reaches colder layers of air. The moisture in the air is condensed and falls as rain. Mountainous districts, then, are usually wet, *e.g.* Snowdon has an annual rainfall of about 200 in., while the plains at its foot have only 30 to 40 in. Even low hills in relatively dry areas will have more rain than the surrounding plains. The North and South Downs, for example, have just over 30 in., while the plains on either side

have just under 30 in. This can be seen on a rainfall map of the British Isles.

(*b*) CONVECTION.—Hot air naturally tends to rise. As it rises it is cooled and rain falls, even though there are no mountains near. Since the air at the equator is always hot it is continuously rising, and rain falls almost every day. In summer, the interior of the northern continents also develop high temperatures, and the rainfall of these regions is therefore mainly summer rain of the convectional type. Thunderstorm rain is also due to convection or uprising currents of over-heated air. In England 76 per cent. of the thunderstorms occur in June, July, and August, 30 per cent. being in July, *i.e.* thunderstorms are most frequent in the hottest months. Large urban areas with their absence of vegetation, large expanses of bare brick and stone, tar macadamised roads, and factories, etc., seem to accumulate heat so that thunderstorm frequency is greater in places like Birmingham, Manchester, and London than it is in rural areas.

(*c*) DEPRESSIONS.—In the westerly wind belt of the temperate zone there are "breaks" in the general distribution of pressure and winds. These are depressions and anticyclones, the former being associated with rain, while the latter are associated with fine weather conditions.

Depressions are large areas of low pressure which approach Britain from the Atlantic, and which bring rainy and stormy weather. They are due to the meeting of streams of warm equatorial air and cold polar air. The warm air being lighter tends to rise over the heavier cold air, and condensation takes place resulting in rain. Since these depressions cross the ocean, rain falls heavily between America and the British Isles, and here again it is well to note that mountains are in no way responsible for the rainfall over the ocean.

In England the mercury in the barometer falls as a "depression" approaches; hence the falling barometer is a sign of rainy weather. Cyclones are roughly oval in shape, and may be nearly 1,000 miles from end to end. There is low pressure in the centre and high pressure round the edges. The winds blow inwards to the low pressure centre but with much deflection to the right of a direct course to the centre, owing to the

earth's rotation. In the Southern Hemisphere this deflection is to the left. This law is known as *Ferrel's Law*. The wind direction tends, therefore, to be "diagonally" across the isobars.

Many depressions of temperate latitudes contain what is called a *warm sector*, *i.e.* a mass of warm air blowing more or less obliquely between currents of colder air on either side [Fig. 97 (*a*)]. As the depression moves forward the warm sector moves with it.

The forward boundary of the warm air at ground level is called a *warm front*, since when it reaches a place the temperature there rises. The rearward boundary at ground level is called a *cold front*, since its passage is marked by a fall in temperature.

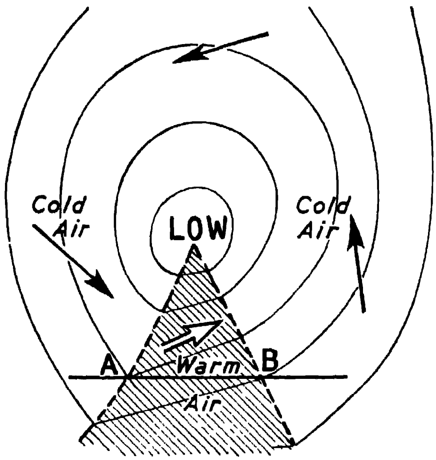


Fig. 97 (*a*). A Depression with a Warm Sector.

A cold front moves forward faster than a warm front so that the warm sector is gradually pinched out by being lifted clean off the ground. In Fig. 97 (*b*), which is a vertical section along the line AB in Fig. 97 (*a*), it will be seen that the surfaces of separation between the warm and cold air are not vertical but sloping. At the forward boundary the warm air rises gently and steadily over the cold air (often at a slope of about 1 in 150), but at the rearward boundary the cold air undercuts the warm air more steeply (perhaps 1 in 80) and less regularly.

The ascending warm air at the forward boundary gives rise to thick layer clouds [Fig. 97 (*c*)] and steady rain which precede the arrival of the warm front at ground level. A cold front brings a shorter period of heavier showery or thundery

rain, followed by clearing skies with, however, perhaps further scattered showers. In a warm sector the sky is usually cloudy or overcast and there may be some drizzle but not as a rule any rain.

When a warm sector has been lifted clean off the ground it is called an *occlusion*, which continues to give much cloud

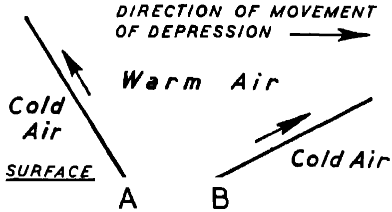


Fig. 97 (*b*). Vertical Section through a Warm Sector.

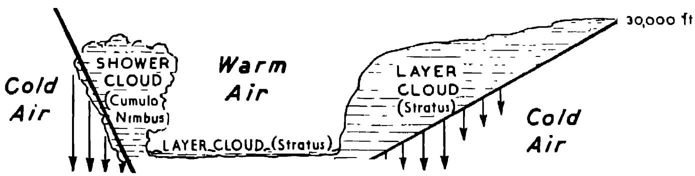


Fig. 97 (*c*). Clouds and Precipitation Associated with a Typical Warm Sector Depression.

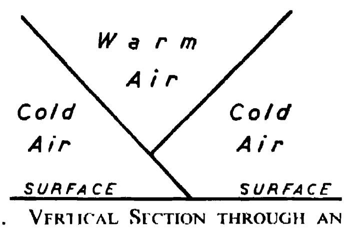


Fig. 97 (*d*). Vertical Section through an Occlusion.

and often a good deal of rain. Warm and cold fronts, and occlusions, are marked on weather maps, such as those given in daily newspapers, and on television, by characteristically-shaped lines (see Fig. 98).

Anticyclones are areas of high pressure, associated with spells of fine weather, hot in summer, and clear, frosty weather

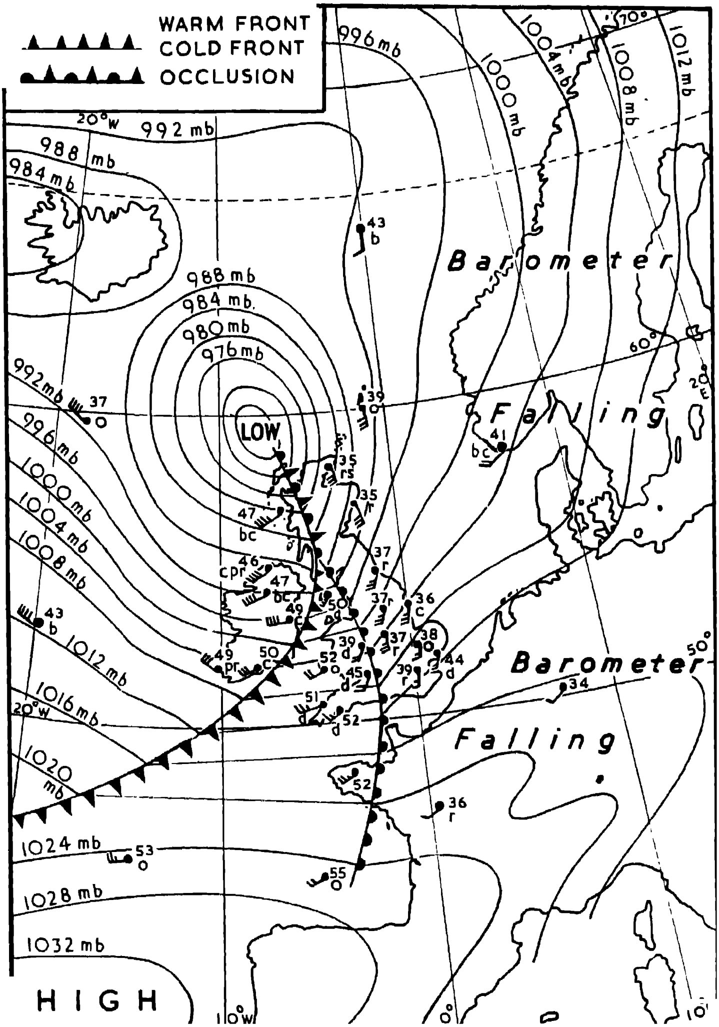


Fig. 98. Cyclonic Conditions.—30th Dec., 6 h. A deep depression, centred off N.W. Scotland is moving north-east, and the associated warm sector is moving across England and Wales. Note the wind veers at the fronts, the rain in advance of the warm front, the drizzle in the warm sector, and the showers and broken cloud behind the cold front. Temperatures in the warm sector are much higher than those in advance of it. The air behind the warm sector is not as cold as that in front of it owing to its passage over the relatively warm ocean.

in winter. Sometimes, however, winter anticyclones last for some days with a uniform layer of cloud. Dense fogs may also persist at such times, due to an inversion of temperature. As an anticyclone approaches, the barometer rises, hence, in England, a rising barometer is usually a sign of fine weather in the sense that rain is less probable. At times a rise occurs when a relatively narrow wedge of high pressure comes between the two depressions. The improvement in the weather is then of short duration as the second depression soon approaches, causing a further rainy period. The high pressure of an anticyclone is surrounded by low pressure, and winds blow outwards from the central high pressure, but still conforming to Ferrel's Law. Figs. 98 and 99 show a typical depression and a typical anticyclone.

The wind directions are indicated by arrows and their strengths in terms of the Beaufort Scale by the length and number of feathers, a short feather representing one unit, and a long feather two units, on the scale, *e.g.*

⊙ = calm (Force 0); = light air (1-3 m.p.h., Force 1),
= light breeze (4-7 m.p.h., Force 2),
= fresh breeze (19-24 m.p.h., Force 5),
= whole gale (55-63 m.p.h., Force 10),

with obvious intermediate gradations.

The appearance of the sky, type of precipitation, visibility, ground and electrical phenomena are given by a simple code known as the *Beaufort Letters*, e.g.

b = blue sky; *c* = cloudy (*i.e.* broken clouds).
o = overcast; *g* = gale.
r = rain; *s* = snow; *rs* = sleet.
p = passing showers; *d* = drizzle.
h = hail.
l = lightning; *t* = thunder.
f = fog; *m* = mist.
v = unusually good visibility.
w = dew; *x* = hoar frost.

Pressure is shown by isobars at 4 mb. intervals (page 171) and the barometric tendency is written in full. A pressure of 1,000 mb. = 29·53 in. and over the British Isles the range is

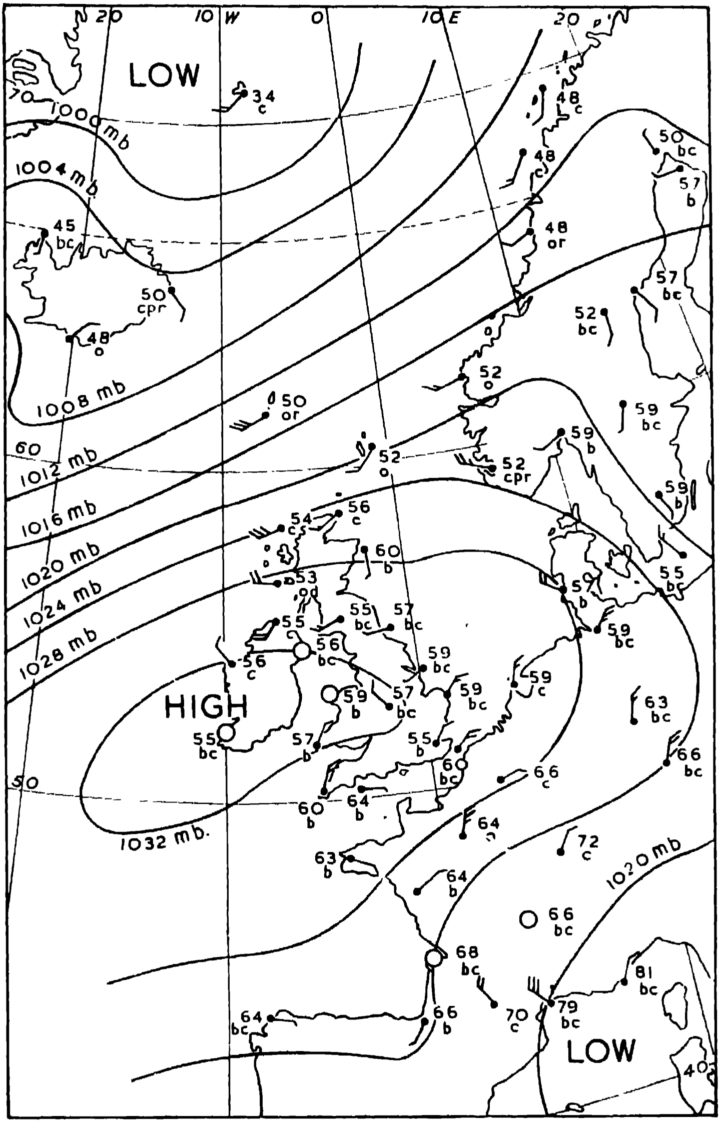


Fig. 99. ANTICYCLONIC CONDITIONS.—17th July, 7 h. On this occasion the forecast was several days' fine weather.

normally from 970 mb. to 1,030 mb. though unusually low or high pressures may be recorded for brief spells.

It should be noted that the greater the pressure gradient (*i.e.* the closer the isobars are together) the stronger the wind force. The numbers inserted at observation stations give the temperatures in ° F.

Taking the weather map (Fig. 98) Valentia (South-West Ireland) records 49° F. temperature, 1,006 mb. pressure, west-north-westerly wind, with passing showers of rain.

In the Daily Weather Report issued by the Meteorological Office a scale of 1 : 20,000,000 is used for the British Isles and Western Europe with the North Atlantic as far west as Greenland. On these maps, winds, barometric pressures, and temperatures are given as explained above, but the weather is recorded by using International symbols in place of the Beaufort letters. A key to these symbols is given in the *Observer's Handbook*.

While rainfall may be due to any of the foregoing causes, the actual amount of rain that falls in a given place is due to a number of other factors.

Coastal lands generally have more rainfall than the interiors of continents where most rain occurs in the summer months and frequently in the form of thunderstorms.

If the prevailing winds are from the sea there will be heavier rainfall than if they are from the land. A comparison of the conditions on the east and west coasts of Australia or in Southern Chile and Patagonia may be taken to illustrate the difference.

Winds from the sea moving towards cooler latitudes are more likely to deposit rain than those drawn towards warmer latitudes. The westerly winds of cool temperate lands, for instance, will be more effective than the Trade Winds blowing towards the tropics.

Mountainous areas will generally have more rain than lowlands and the windward sides of mountains heavier rainfall than the leeward sides. The Khasi Hills of India afford a striking example of both these effects. At Sylhet, on the plains, a fall of 106 in. occurs during the summer monsoon; at Cherrapunji (4,400 ft above sea-level) the fall is three times as great, but at Shillong, only 25 miles distant, but on the lee side of the mountains and at a higher altitude, the fall is 55 in.

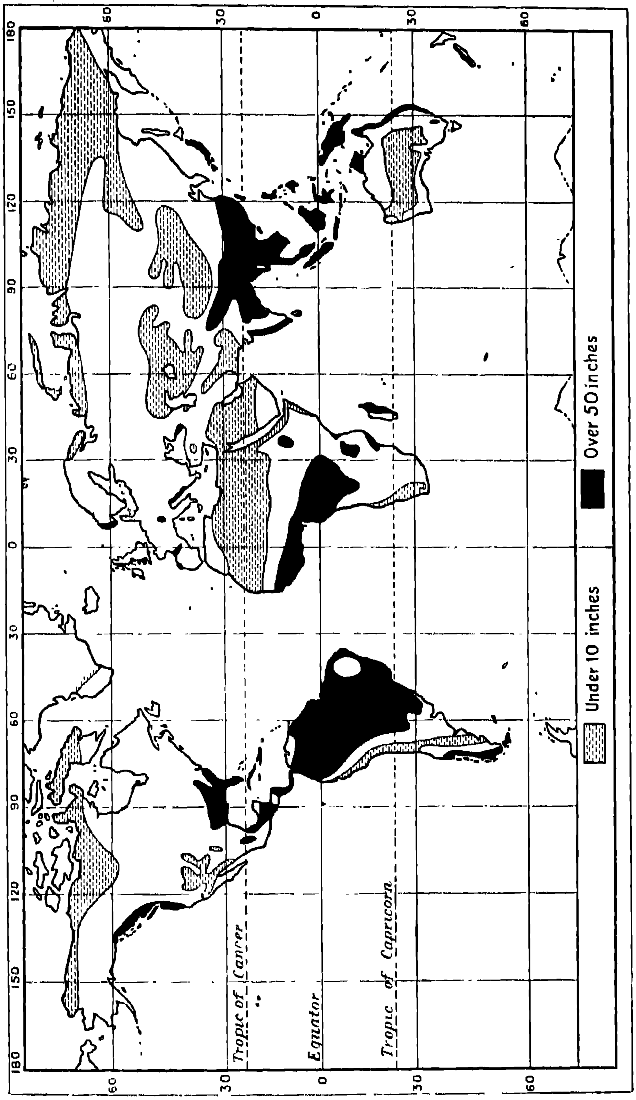


Fig. 100. THE AREAS OF HEAVY RAINFALL (OVER 50 IN. ANNUALLY) AND SCANTY RAINFALL (UNDER 10 IN. ANNUALLY).

Even in the desert areas the effect of altitude can be traced. Nejd, in the centre of Arabia, is sufficiently high to receive more rain and support a pastoral community, while the lower parts of the plateau to north and south are inhospitable deserts. Similarly in the heart of the Sahara, the Tibesti Highlands have some summer rain and snow may cover the summits in winter.

When sea winds pass over a warm current they pick up more water vapour, and so the rainfall of the coastal lands is increased, *e.g.* South-East United States, but when on-shore winds first cross a cold current they pick up less moisture, or may even be forced to drop moisture, and so drop less rain on the neighbouring coasts. This influence of cold currents is well marked in South America (desert of North Chile and Peru) and in South Africa (Namib Desert).

When studying rainfall conditions it is necessary to notice not only the annual amount but also the *seasonal* distribution which has a marked bearing upon the type of vegetation. Temperature conditions must also be considered, for a fall of 20 in. may be sufficient for cereal cultivation in high latitudes. but in the tropics the same amount would be inadequate. Again, rain occurring in the form of thunderstorms is less effective than light rains at frequent intervals, while precipitation in the form of snow can be an advantage as the ground temperatures do not fall so low and the melting of the snows in spring provides the moisture upon which the vast forests of Canada and Siberia depend. Thus the amount, seasonal distribution, and type of rainfall all influence the distribution of products and this, in turn, has a direct bearing upon human activities.

CHAPTER XI

CLIMATIC FACTORS—III. PRESSURE AND WINDS

Measurement of Pressure

The weight and pressure of the atmosphere is measured by means of a barometer. At sea-level the mercury in a barometer measures about 30 in. (760 mm.). On modern weather maps the unit taken is 1 bar, which is divided into 1,000 millibars. One bar is equivalent to a barometer reading of 29·53 in. The barometer (at sea-level) rarely falls below 28 in. (950 mb.) or rises above 31 in. (1,050 mb.).

Pressure readings are taken daily at specified times, and the average found over a number of years, as in the case of temperature. Pressure maps are constructed by joining all places of the same air pressure. An *isobar* is a line joining all places of the same pressure at the same time (see Figs. 98 and 99). The term "high pressure" is used to denote the state of the atmosphere when the barometer reads about 30 in. or over, and the term "low pressure" is used when the reading is about 29 in. or less.

During the ascent of a mountain the mercury in the barometer falls, for not only is there less air above, but the air is becoming less dense. At a height of 18,000 ft or about 3½ miles, the barometer would only read 15 in. (500 mb.), because half the atmosphere, by weight, is below this level and the other half above. This does not mean that the thickness of the atmosphere is seven miles, because the air becomes less and less dense away from the earth. There are probably traces of air at a height of 200 miles, but our knowledge of the stratosphere is incomplete, and man has, as yet, only ascended to a height of 13·7 miles (Fig. 101).

Planetary Winds

Although at any place pressure varies from day to day, the general distribution of air pressure over the world as a whole follows a general plan. The hottest part of the earth is always

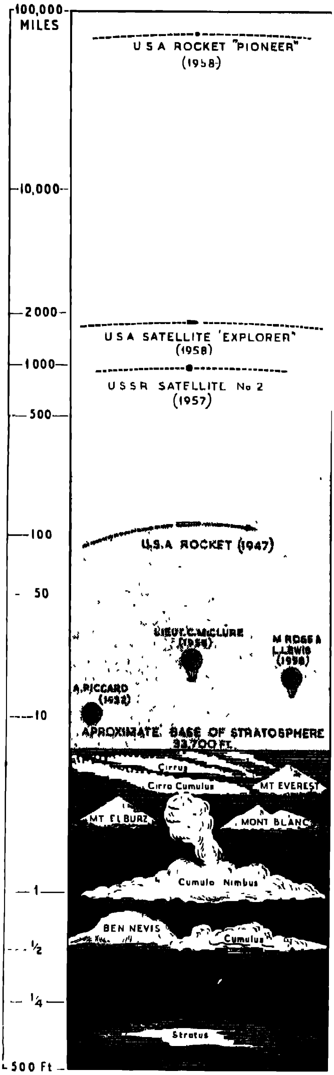


Fig. 101 Various record heights compared with clouds and mountains. Note that the scale of heights is not linear but logarithmic.

somewhere near the equator. Thus the air in these regions is heated more than elsewhere. Hot air always rises, and so the air at A (Fig. 102) rises in the direction of AB. Currents of air move towards the equator from the north and south to take the place of the rising air, and this air is, in turn, heated and forced to rise. The rising air, in time, cools, and moving north and south in the direction shown by the arrows, gradually sinks to the earth at C and D (about 30° N. and 30° S.), whence some of it proceeds polewards and some equator-wards, as shown in the diagram.

These currents of air are termed *convection currents*. The streams of air moving along the earth's surface are winds, and so we can see that, on a globe composed uniformly of land and water, four winds would result, as shown by dotted lines in the diagram. Owing, however, to the rotation of the earth, these winds are deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. (To realise which is left and right you must stand facing the direction towards which

the winds are blowing.) As a result of this deflection the planetary winds assume the direction shown by the arrows in Fig. 103.

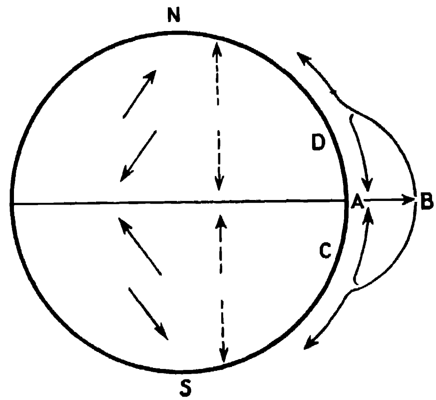


Fig. 102.

Where the air rises at the equator the pressure of the atmosphere is low. This is a region of calms called the Doldrums. Where the air is descending and heavy, the pressure is high. These regions of high pressure are called the Horse Latitudes. Winds always blow from high pressure to low pressure. The two sets of winds blowing towards the equator from the north and south are called the N.E. and S.E. Trade Winds (not because they help "trade" but because they blow persistently over a

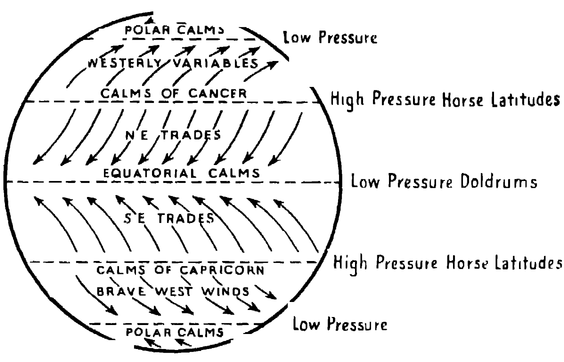


Fig. 103. PERMANENT WINDS AND CURRENTS.

"trodden" path). The winds blowing polewards from the high pressure belts are known as Westerly Variables, mainly S.W. in the Northern Hemisphere and N.W. in the Southern

Hemisphere. In the south temperate zone there is so little land that the westerly winds blow without interruption and with great force. The latitudes 40° S. to 50° S. are, on this account, known as the Roaring Forties, and those in latitudes 50° to 60° as the Furious Fifties.

Unfortunately, this relatively simple plan of world pressure and winds is broken as a result of the unequal heating and cooling of land and water.

Land and Sea Breezes

During the day the land becomes hotter than the sea, and the air over the land rises. During calm, hot weather a cool current of air moves in from the sea to take the place of the rising air over the land. This is a sea breeze which mainly

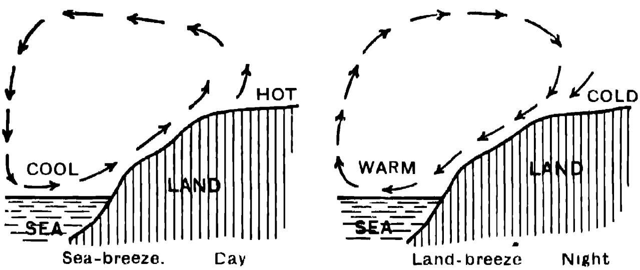


Fig. 104.

blows during the daytime. At night, however, the land cools quickly so that it is colder than the sea, and the air stream (in calm, cloudless weather) is reversed, producing a land wind blowing out to sea. These breezes may be observed at English seaside resorts during spells of calm, fine weather. They are also well marked around the coastline of the Eastern Mediterranean. Land and sea breezes are rarely perceptible more than a very short distance inland.

Monsoons

Monsoons may be regarded as land and sea breezes on a continental scale. The word "monsoon" is derived from an Arabic word meaning "season". Instead of winds varying from day to day, they vary from season to season, *i.e.* from summer to winter; the winds blowing from sea to land in summer and land to sea in winter.

The monsoon system is associated with the lands of South-East Asia, Eastern Africa, and Northern Australia. The conditions which appear to be necessary for monsoons are: —

(*a*) A land mass of considerable extent.

(*b*) An almost east to west trending coastline in tropical or warm temperate latitudes.

(*c*) An extensive ocean on the equatorial side of the land mass.

In *summer* the land is hotter than the sea, there is, therefore, low pressure over the land and high pressure over the sea. The winds blow from high to low pressure, *i.e.* from the sea to the land, and are therefore wet winds.

In *winter* the conditions are reversed. The land is colder than the sea, so that there is high pressure over the land and low pressure over the sea. The winds blow from high to low pressure, *i.e.* from land to sea, and are therefore dry winds. The above is a simple explanation of the principle underlying monsoons, but in Asia there are really two monsoon systems. The first has its centre of origin in Central Asia, north of the Himalayas, and the second in North-West India.

(1) The most widespread monsoon system of Asia is that which affects all South-East Asia except India, viz. Indo-China, China, and Japan. Its centre of origin is Central Asia. During the summer, winds are drawn in to the low pressure area of Central Asia and blow as south-westerly winds in Siam, southerly and south-easterly winds in China, and as easterly winds in Japan and Manchuria. These wet inblowing winds deposit rain over all the lands of South-East Asia (except India) and, in general, the amount of rain decreases from South China northwards.

In winter the monsoon blows from the land, and is a very strong and bitterly cold wind. In Siam it is north-easterly, in China northerly and north-westerly, and in Japan and Manchuria westerly.

(2) The Indian monsoon is quite distinct from the general monsoon of the remainder of South-East Asia. The Himalayas are so high that they project into the stratosphere (above the level of the usual planetary winds), and so they form an effective meteorological barrier between India and Central Asia.

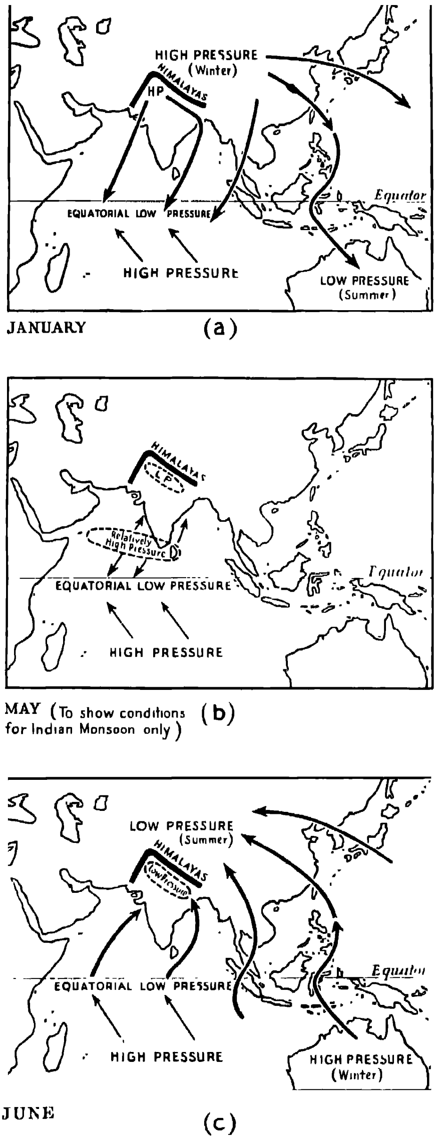


Fig. 105. THE WINDS OF THE MONSOON AREAS.

In January [Fig. 105 (*a*)] a weak high pressure system develops over the Punjab (North-West India) and from this the Indian winter monsoon originates. The north-east winter monsoon is a gentle wind blowing 3 or 4 miles an hour, and it is not bitterly cold, as it would be if it originated to the north of the Himalayas.

In May [Fig. 105 (*b*)] low pressure conditions are developing over Northern India, but in the latitudes of the South Deccan high pressure still persists, forming a meteorological barrier between the low pressure at the equator and the low pressure of the Punjab. The light south-west winds which commence to blow bring rains to the South-West Ghats, especially in the

neighbourhood of Calicut, where they are known as "Mango" showers.

In June [Fig. 105 (c)] the high pressure over the Deccan has disappeared because of the rising temperature, and the low pressure of the Punjab has become more intense. The disappearance of the high pressure barrier in Southern India marks the "breaking" of the monsoon. The winds from the sea (the south-west monsoon) blow uninterruptedly northwards to the Punjab "Low", and cause heavy rain over most of India. Even in Southern India there is a marked change from the light mango showers to the torrential rains of the monsoons. During the rainy season the heaviest rainfall occurs along the west coast and in the lower Ganges Valley.

(3) The monsoon system of North Australia is closely associated with the Indian monsoon. In January the dry, outblowing winter winds from Asia sweep southwards across the equator and reach Northern Australia after crossing a vast expanse of ocean. They reach Northern Australia as wet north-west winds, during the summer months of the Southern Hemisphere. In July the conditions are reversed. Northern Australia, experiencing winter conditions, has a dry, outblowing south-easterly wind, which blows northward across the Indian Ocean, and reaches Asia as the wet south-west or south-east summer monsoon.

Föhn Winds

High mountain ranges usually act as barriers to the winds of the lowland areas on either side of them, but in certain circumstances a wind may ascend one slope and descend on the other side. On its upward journey it cools and is forced to drop most of its moisture. As it descends on the other side it warms up again and, having now little water vapour, its temperature when it reaches the lowlands is considerably higher than at the same level on the other side of the range. Such winds are, therefore, warm and very dry. They are common in Swiss valleys on the north side of the Alps, where they are known as Föhn winds. In spring they cause snow to disappear very quickly and thus make pasture available for animals sooner than would otherwise be the case.

Similar winds blowing eastwards across the prairies of North America from the Rockies are known as *Chinook* winds.

Tropical Cyclones

Towards the end of the summer, tropical depressions or *typhoons* are apt to form over sea areas in the Doldrums. The isobar pattern is similar to that of temperate region depressions (page 162) but there is no warm sector and the depression has a very much smaller diameter, rarely as much as 500 miles across and usually very much less. The isobars are very close together, however, and, owing to the steep pressure gradient, wind speeds are very high, often exceeding 100 miles per hour. These storms move westwards and pole-wards along fairly regular tracks and bring great devastation to islands and coastal areas in their path (*e.g.* West Indies and South-Eastern United States), but die out rapidly overland.

Tornadoes

Tornadoes are local whirlwinds, varying in diameter from a few yards to about a quarter of a mile, which are apt to form inland in very hot thundery weather. Wind speeds are exceptionally high and tornadoes destroy everything in their path. Fortunately they do not as a rule travel far, and die out almost as suddenly as they start.

CHAPTER XII

NATURAL REGIONS

Introductory

In Chapter II reference was made to the migration of the overhead sun between the tropics according to the seasons, and in Chapter XI the planetary system was described. But the arrangement of winds depicted in Fig. 103 refers only to the equinoxes, when the sun is overhead at the equator and the region of maximum heat is almost coincident with that line.

As the overhead sun migrates north and south between the tropics it is followed by the belts of greatest heat (Fig. 106), and consequently by the belts of lowest pressure in which the planetary wind system originates. The consequent north and south migration of the whole of the planetary winds is known as "the Swing of the Wind System".

The Swing of the Wind System

In July, the sun is overhead north of the equator, and the hottest area lies north of the equator at B [Fig. 107 (*b*)]. This means that the area where the hot air rises is north of the equator, with the result that the whole wind system is further north than at the equinoxes.

In January, the sun is overhead south of the equator, the heat belt is south of the equator at C [Fig. 107 (*a*)], and as a result the whole of the wind system is further south than at the equinoxes. This north and south movement of the equatorial heat belt has very important consequences, for, as a result of this "swing", certain places do not have the same wind at all seasons of the year, as would be the case if the wind belts remained constant. The results are most marked on the western sides of continents.

South-westerly winds in the Northern Hemisphere and *north-westerly* winds in the Southern Hemisphere are blowing polewards, and therefore becoming cooler. Thus they are losing their capacity for holding moisture, and tend to drop rain. We can consider them to be mainly wet winds when they blow from the ocean to the west coasts of continents.

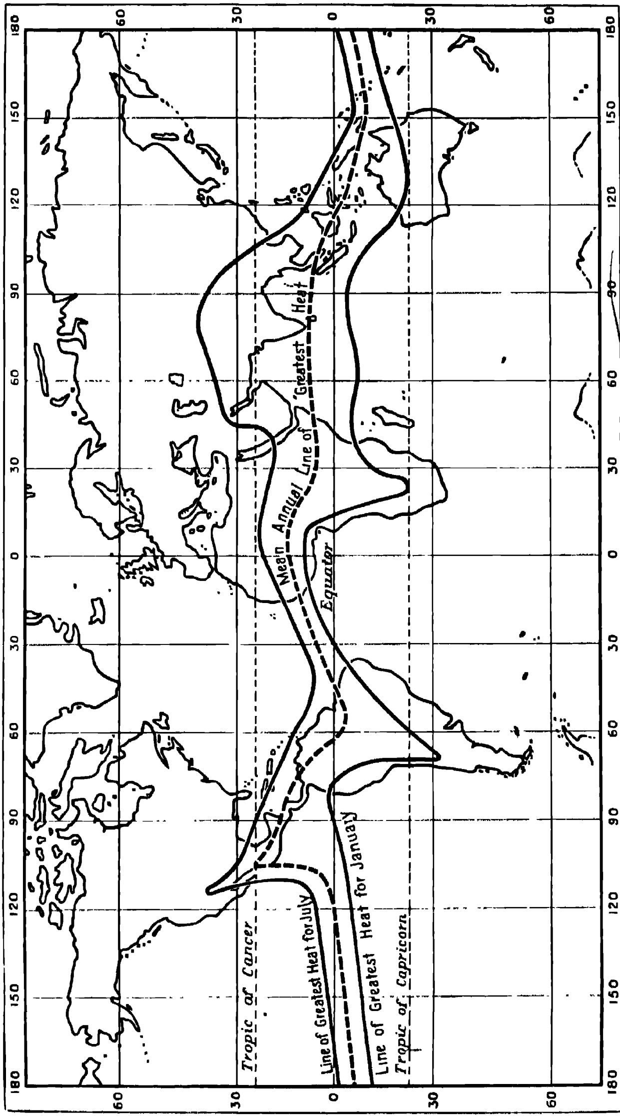


Fig. 106.—The Heat Equators.

Trade Winds are blowing equator-wards and becoming hotter. Thus they increase their capacity for holding moisture, and tend to pick up moisture rather than to drop rain. These can, therefore, be considered as drying winds, bringing with them fine weather and low rainfall, except where they meet high mountains (*e.g.* in British Guiana).

High pressure areas, like anticyclones, are regions of fine, dry weather.

Low pressure areas, such as the Doldrums around the equator, are regions of rising and cooling air and heavy rain.

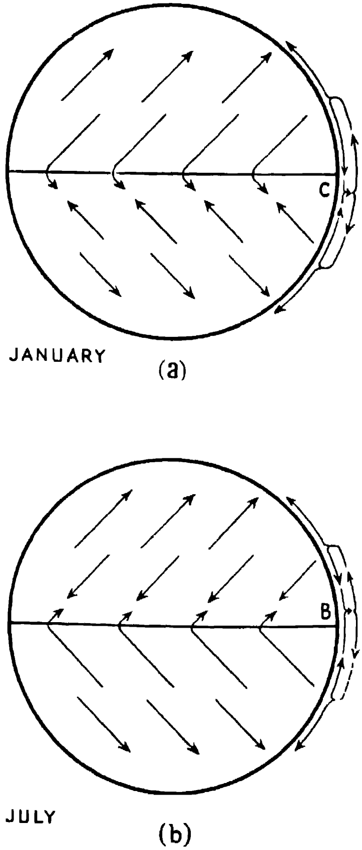


Fig. 107. DIAGRAM TO SHOW THE MIGRATION OF WIND BELTS NORTH AND SOUTH OF THE EQUATOR.

In Fig. 108 the unbroken lines denote the wet westerlies, the broken lines are the drying Trade Winds, and the low pressure areas are rainy regions. You will notice that the July winds are drawn further north than the January winds, because of the "Swing of the Wind System". The belt indicated by C has westerlies during the winter, so that the winters are wet; and trades during the summer, so that the summers are dry. This region of wet winters and dry summers is known as a "Mediterranean region", because it is the typical climate of lands bordering the Mediterranean Sea. This type of climate does not extend across the centre and

east of a continent because the westerlies are no longer rain-bearing after they have crossed large stretches of land. Thus Fig. 108 refers only to the western margins of continents. The other west coast belts can be worked out from the diagram,

		1 July (Summer)	2 Jan. (Winter)	3 Winds	4 Rainfall	5 Type
NORTHERN HEMISPHERE	A			Stronger westerlies in summer than winter	Light summer rain	Tundra
	B			Westerlies in winter Westerlies in summer	Wet winters Wet summers	British
	C			Westerlies in winter Trades in summer	Wet winters Dry summers	Mediter ranea
	D			Trades in winter Trades in summer	Dry winters Dry summers	Desert
	E	Low Pressure		Trades in winter L.P. in summer	Dry winters Wet summers	Savana
	F	Low Pressure	Low Pressure	L.P. in summer L.P. in winter	Rain all year	Equa- tori:
SOUTHERN HEMISPHERE	E		Low Pressure	Trades in winter L.P. in summer	Dry winters Wet summers	Savana
	D			Trades in winter Trades in summer	Dry winters Dry summers	Desert
	C			Westerlies in winter Trades in summer	Wet winters Dry summers	Mediter ranea
	B			Westerlies in winter Westerlies in summer	Wet winters Wet summers	British
	A			Stronger westerlies in summer than winter	Light summer rain	Tundra
		July (Winter)	Jan. (Summer)			

Fig. 108.

CLIMATES ON THE WESTERN MARGINS OF CONTINENTS.

and it must be noted that the sequence of climate is the same from the equator northwards and southwards, and that regions with similar climates occur in approximately the same latitudes north and south of the equator.

Natural Regions

The types named in column five are some of the divisions of the world that are termed "natural regions". *A natural region is one throughout which the conditions of relief, temperature, rainfall, natural and cultivated vegetation, and consequently human activities, are almost uniform.*

In the following pages a very simple scheme for dividing the world into natural regions is outlined. At first no allowance will be made for mountain masses, which, because of their altitude, have climates differing from those of the surrounding plains both in temperature and rainfall.

When, however, the simple scheme has been mastered, mountains must be taken as a special group of natural regions, varying with latitude, and, since they act as wind barriers and rain divides, these mountainous areas will be the dividing zones between other natural regions. For example, the Rockies of Canada divide the equable climate of British Columbia from the continental climate of Central Canada. The Rockies, however, are not a single mountain chain, but a wide mountain mass, and have a distinct climate of their own.

Examine Fig. 109. Suppose that the rectangle represents a continent lying mainly north of the equator.

Firstly, divide it into four zones according to latitude, viz. (1) the cold zone north of the Arctic Circle; (2) the cool temperate zone from latitude 45° N. to the Arctic Circle; (3) the warm temperate zone from latitude 30° N. to 45° N.; (4) the hot zone between the equator and 30° N. Then divide each of the temperate belts into three sections so as to give a western, central, and eastern area in each belt. In the hot zone, cut off a strip for the equatorial area, and then again divide the remainder into three sections, noting carefully that on the west coast the desert area does not touch the equatorial area.

The same principles of subdivision can be applied to the southern continents, but it must be remembered that their narrowness does not always allow subdivision into three sections, the central section being crowded out. For instance, in the cool temperate zone of South America there is no central section with a climate similar to that of Central Canada.

The value of studying the world from the point of view of natural regions has many advantages. If the natural conditions (rainfall, temperature, vegetation, etc.), of the British type are known for Europe, then they can readily be applied to the cool temperate western margins of any other continent,

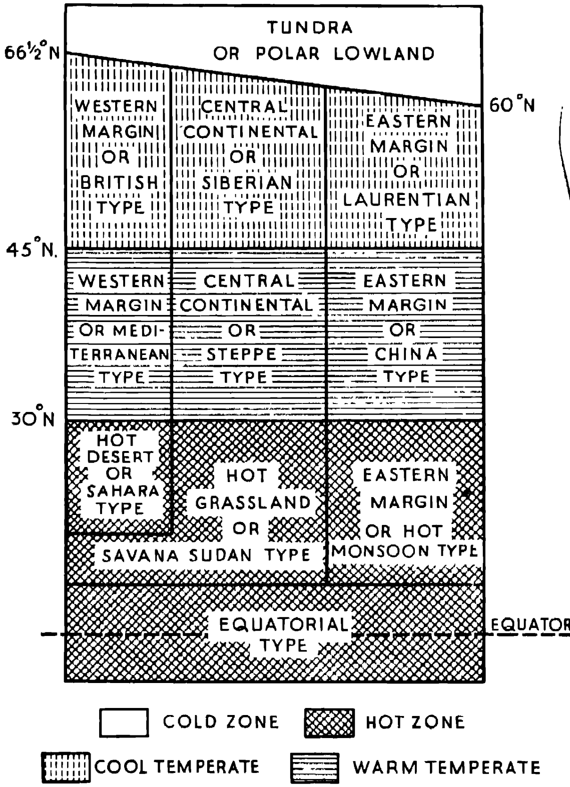


Fig. 109. SIMPLE SCHEME OF NATURAL REGIONS.

for they will be similar for any other region of the same type.

Fig. 110 is a simple rainfall diagram based on the same division of a continent into natural regions. It shows both the seasons in which rain falls and the season of maximum rainfall. In the case of summer rain areas the closeness of the shading shows that Monsoon areas have more rain than

Savana areas, and Savana areas have more than Steppe and Siberian regions.

The Rainfall of the Major Natural Regions

At this point it may be useful to classify some of the main rainfall regions of the world.

A. RAIN ALL THE YEAR.—The regions which have rain all the year round may be classified as follows:—

(1) *The western margins of continents in the cool temperate belt.* Here the rainfall is brought by the prevailing westerlies,

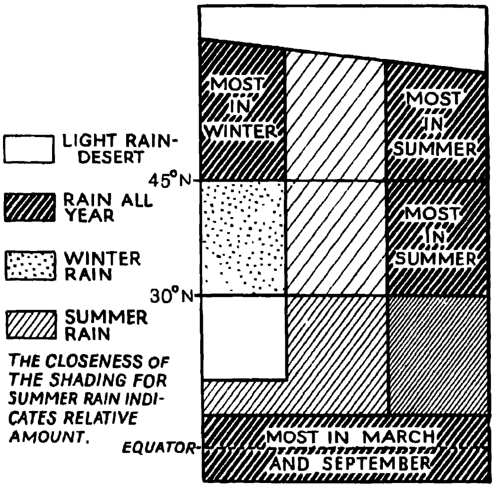


FIG. 110. RAINFALL.

and is either relief rain or cyclonic rain. The maximum rainfall occurs in winter, and except on lee side of mountain masses it is large in amount, *e.g.* Snowdon has as much as 200 in. annually. (See page 196.)

(2) *Equatorial lowland areas.* These areas include the districts where the rainfall is heavy and of the convectional type. Maxima occur just after the period of the overhead sun (the equinoxes).

(3) *The eastern margins of continents in both cool and warm temperate latitudes.* The rainfall is mainly monsoonal

in Asia but in North America is also due to the passage of depressions. The amount varies, being lighter in the higher, and heavier in the lower, latitudes. The maximum rainfall is in summer.

B. SUMMER RAIN.—In the three following regions, rain occurs only in the summer months:—

(1) *Continental interiors of the cool and warm temperate zones.* The rainfall is light (20 in.) and is mainly convectional in type.

(2) *The Savana regions north and south of the equatorial areas.* The rainfall is convectional, and is due to the north and south migration of the equatorial low pressure belt. It varies in amount from 10 in. on the desert edge to 60 in. on the equatorial forest borders.

(3) *Monsoon lands.* In these regions the rainfall is due to in-blowing summer monsoons, and varies greatly in amount. The heaviest recorded rainfall is at Cherrapunji in the Assam Hills, with a mean annual rainfall of 458 in., though as much as 905 in. has been recorded in one year (and 40 in. in a single day). Some parts of the monsoon lands have light or scanty rainfall. The rainfall of the Deccan is less than 40 in., and that of the Thar Desert in North-West India is less than 10 in.

C. SCANTY RAINFALL.—There are two types of regions where rainfall is scanty. They are:—

(1) *The polar lowland.* In these areas the rainfall is less than 10 in. The maximum occurs in summer, and winter precipitation is usually in the form of snow.

(2) *Hot deserts on the western margins of land masses in the hot zone.* The rainfall is again less than 10 in., but the period of maximum rainfall varies, *e.g.* in the north of the Sahara near the Mediterranean the maximum tends to occur in winter, but on the south side of the Sahara, near to the Savana regions, the maximum is in summer.

D. REGIONS OF WINTER RAIN.—The only examples are to be found on the western margins of continents in the warm temperate zone, viz. "Mediterranean" areas. The rainfall is moderate (20 in.-30 in.), and the bulk of it falls during the winter months. At least one or two (and often more) summer

months are virtually rainless, and near the desert borders, *e.g.* in North Africa, there may be seven months with a rainfall of less than 1 in.

The Vegetation of the Major Natural Regions

Fig. 111 shows the characteristic vegetation of the natural regions. Remember that in many areas the natural forest has been cleared and crops are grown, while much of the grass-land has also been cultivated.

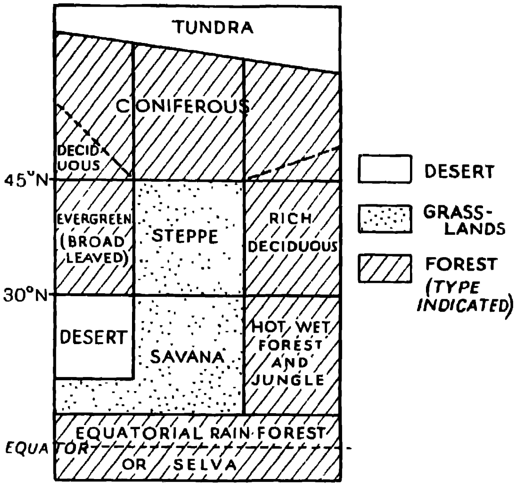


Fig. 111. VEGETATION.

The natural vegetation of the world may be divided into forests, grass-lands, deserts. These in turn may be subdivided.

(*a*) FORESTS.—(1) *Cool Temperate.* Coniferous; deciduous.
(2) *Warm Temperate.* Richer deciduous; broad-leaved evergreens.
(3) *Hot.* Monsoon; equatorial.

(*b*) GRASS-LANDS.—(1) *Warm zone.* Steppe—these extend into the cool zone where there is deficient rainfall.
(2) *Hot zone.* Savanas.

(*c*) DESERTS.—(1) *Cold.* Tundra.
(2) *Hot.* Trade Wind Deserts.

The vegetation of a region varies according to the temperature, rainfall, and soil conditions. A number of factors are necessary for the growth of vegetation, but the two most important are warmth and moisture. Warmth varies mainly with latitude, but the amount of moisture available for plant growth cannot be judged absolutely by a mere consideration of the rain that falls in a given region. Some of the rain runs off the surface to feed rivulets and streams, and some is evaporated and the remainder percolates into the ground. It is the amount available in the surface layers of the ground that helps to determine the characteristic vegetation of a region. This is well seen in the prairies where cotton trees line the streams of these "treeless" areas. If a region has very high summer temperatures much of the rain is evaporated, leaving relatively little for plant life. Again, since the roots of plants absorb their food in solution, it follows that they must become inactive during any period when the ground is frozen; more than that, most plants cannot obtain plant foods from the ground when the temperature falls below about 41° F. Thus a period of intense cold, is, as far as plant life is concerned, equivalent to a period of drought, since neither during drought nor cold can plants absorb plant foods in solution.

Therefore we find that while 20 in. of rain will support trees in the continental interiors of the *cool* temperate zone, the same amount of rainfall in the continental interiors of the *warm* temperate zone will only support grass (steppe lands). This is because of the increased summer temperatures and the consequent increase in evaporation.

In the hot lands 60 in. of rain is necessary for permanent forest. Where the rainfall is below 60 in. the forest gives way to "park lands", *i.e.* grass-lands interspersed with groves of trees, and as the rainfall still further decreases, to open grass-land, and finally to scrub.

Plants have to adapt themselves to withstand drought, whether it be the drought of scanty rainfall, or the "pseudo drought" which results from low temperatures. Thus deciduous trees shed their leaves during the cold season. In the British type of climate this is a wet season, but the low temperatures limit growth. In other areas of deciduous forest (see Fig. 111) leaves are also shed in the "cold" season, but in these regions the cold season is also the drier season.

Conifers combat the cold by reducing the size of their leaves. All conifers have needle-shaped leaves which they retain throughout the year.

The broad-leaved evergreens of the "Mediterranean" areas should, if they followed the laws of nature, shed their leaves during the drought of summer. As it is, these trees grow slowly during the mild wet winters, and retain their leaves throughout the summer. They take special precautions, however, against the summer drought by having relatively small, hard, leathery, and waxy leaves, a woody structure, deeply-penetrating roots, and various water and food-storing devices.

In the equatorial forest zone where it is always hot and wet, plants can grow freely throughout the year. There is no period of drought. This forest has the appearance of being always green, since there is no definite season when all the trees shed their leaves. Thus it is possible to see within a short distance of one another, trees in full leaf, trees quite bare, trees in flower, and trees bearing fruit.

CHAPTER XIII

NATURAL REGIONS—THE COLD LANDS

Broadly speaking, the cold lands lie within the Arctic Circle, and may be classified as (*a*) Highland or Ice Cap type, and (*b*) Lowland or Tundra (Fig. 112).

Ice Cap Type

In such regions the land is covered with a mantle of snow and ice all the year round, and is therefore useless to man for agricultural purposes. This type is found in Greenland and the Antarctic continent, and it is only on the coastal margins of Greenland that a few Eskimos have settled.

Tundra or Polar Lowland

Before the tundra regions are described in detail, the climate and vegetation of such areas must be considered.

CLIMATE.—These are treeless plains lying north of the great forest belt of the temperate zone. Trees do not grow where the summer temperature falls below 50° F., hence the southern limit of the tundra is marked by the July or summer isotherm of 50° F. A study of world isotherm maps will show that there are no land areas in the Southern Hemisphere, apart from the Antarctic Highlands, which lie south of the summer isotherm of 50° F. In the Northern Hemisphere the tundra areas are:—

(1) The northern lowlands of Siberia and European Russia.

(2) The northern lowlands of Canada.

Tundra regions have short, cool summers (under 50° F.), and very cold, long winters (usually below 0° F.). The summer days are long and the winter days very short (see Chapter II). The rainfall is light and generally less than 10 in. annually. Most of this rain falls in the summer half-year, when the westerlies are strongest in these regions. In winter, precipitation takes the form of snow, but as it is so cold the snow does not melt. This accumulation of snow tends to give an

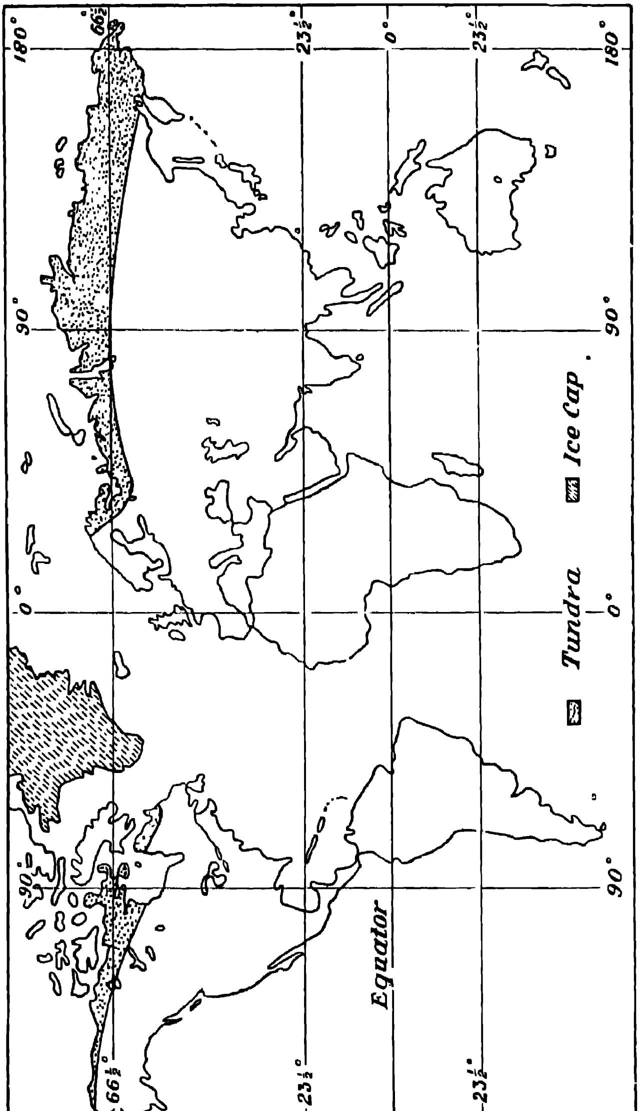


Fig. 112. COLD LANDS.

erroneous impression of the amount of winter precipitation. Even in winter large areas have no snow covering, as a result of the strong winds which sweep the surface quite bare and pile the snow elsewhere into great drifts.

Fig. 113 illustrates the temperature and rainfall conditions of a place on the edge of the tundra. Kola is a town on the north coast of European Russia, and has been chosen because it is difficult to obtain reliable climatic records for the heart of a tundra area. As Kola is near to the moderating influences of the North Atlantic, its winter temperatures are warmer than one would expect in tundra areas. The rainfall

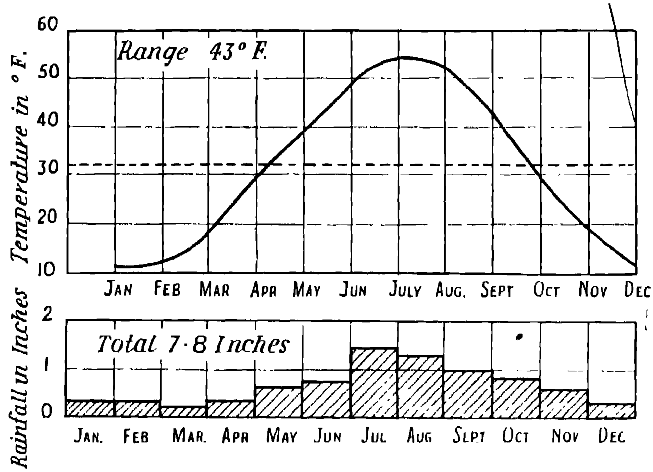


FIG. 113. TUNDRA TYPE. KOLA (33 FT ABOVE SEA-LEVEL).

graph shows how little rainfall (or snowfall) there is during the winter months, and that the average annual rainfall is less than 10 in. Thus tundra areas may be classified as cold deserts, since it is customary to consider as desert lands regions with less than 10 in. of rain.

VEGETATION.—The tundra is covered for the most part with mosses and lichens, but on sunny, south-facing, and well-drained slopes one finds in summer beautiful carpets of flowers, known as "bloom mats". In other localities grow short berry-bearing bushes similar to the bilberries of our moorlands, while along the river courses may be found stunted

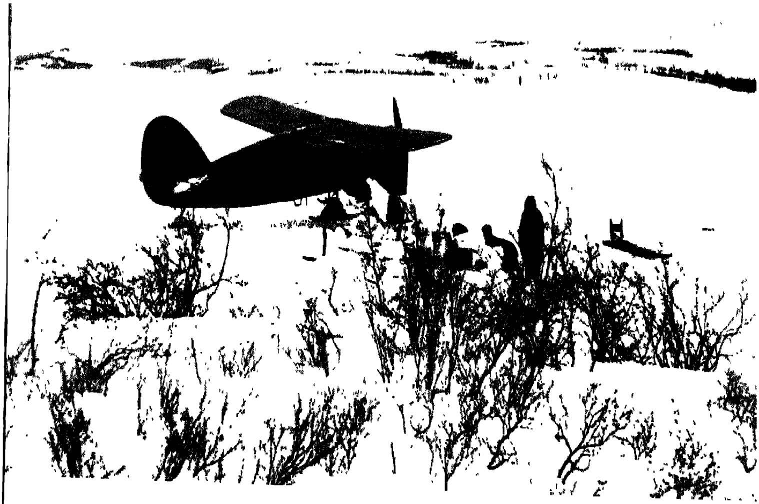


PLATE 19

Above. Tundra in Winter. Note the landing skis on the aircraft. (*National Film Board of Canada.*)

Below. Tundra in Summer. Note the poor drainage, thin soil, and stunted shrubs. (*National Film Board of Canada.*)

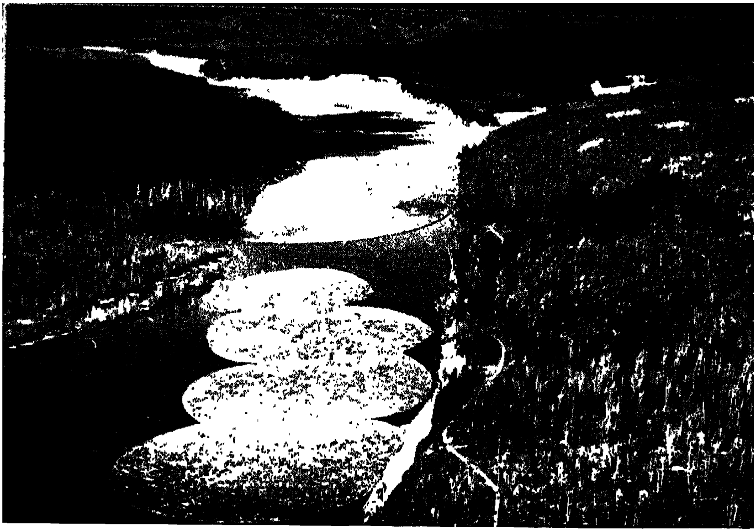


PLATE 20

Above. Coniferous Forest. Note the circular booms of timber, each consisting of about 25,000 logs. These are towed down-stream by tugs. (*National Film Board of Canada.*)

Below: U.S.S.R. Novosibirsk Technical College students at practical work in the fur-dressing room. (*Society for Cultural Relations with the U.S.S.R.*)

birch trees. In these regions agriculture is unimportant because of the shortness and coolness of the summers, and because the ground is frozen for more than half the year. (See plate facing page 192.)

STAGES OF DEVELOPMENT.—The tundra lands do not show any successive stages of development, as they are almost entirely inhabited by primitive peoples.

In the tundra of North America the Eskimo depends on hunting and fishing, and to a slight extent, on recently-introduced herds of reindeer. In contrast, the peoples of the Eurasian tundra depend mainly on their herds of reindeer, but are also engaged in hunting and fishing. Since the reindeer move from place to place in search of food, these peoples (Yakuts, Lapps, and Samoyeds) are nomadic. The western end of the Eurasian tundra has, however, a more accessible coastline, due to the effect of warm currents. In consequence Russia has outlets to the Arctic in the ports of Petsamo, in the hinterland of which is a nickel-producing area, and Murmansk, which proved of great value as a link between the Allies and Russia. A railway connects this Arctic port with Leningrad, while a ship canal joins the Baltic and White Seas. Farther east, ports such as Igarka have been used for the shipment of timber from Siberia, and meteorological stations established in view of the increasing use of aircraft in these latitudes and the efforts made to maintain, with the aid of powerful ice-breakers, a sea route from the Arctic Coast to the Pacific. In Arctic Russia experiments have also been carried out to test the possibility of cultivating the hardier cereals and vegetables, while the presence of minerals (coal and oil) suggests further potential developments.

In North America the construction of the Alaskan Highway brings the tundra region into closer contact with the remainder of the continent. This road, constructed with amazing rapidity, runs from Dawson Creek (B.C.) to Fairbanks.

CHAPTER XIV

NATURAL REGIONS—THE COOL TEMPERATE LANDS

Classification

According to the simple scheme outlined in Chapter XII, the cool temperate lands may be divided into: —

(1) Western Margin or British type.
(2) Central or Siberian type.
(3) Eastern Margin or Laurentian type.

THE COOL TEMPERATE BELT

Vegetation

The cool temperate belt lies between latitude 45° N. and the tundra areas. Except where rainfall is light, as in Southern Alberta, which is sheltered from rain-bearing winds by the Rockies, the whole of the cool temperate zone is a forested area, and is shown on Fig. 111. This forest is mainly of coniferous or cone-bearing trees, *e.g.* pine, fir, spruce, and larch. But where conditions are milder and wetter, as in the plains of Europe, the trees are deciduous, *e.g.* the oak, elm, beech, alder, poplar, etc.

In the deciduous forest belt, conifers are found, (1) where it is colder, *e.g.* on mountains such as the Black Forest or the slopes of the Norwegian mountains; (2) where the soils are light and sandy, as in the New Forest of Hampshire, or Delamere Forest in Cheshire. Where the rock is very porous, as on the Chalk Downs of South-East England, forests rarely grow. In Europe very little of the deciduous forest remains, as the land has been cleared for agriculture, and in Canada much of the coniferous forest has been cut down, both to supply the world's demand for timber and to make room for wheat growing and general farming.

WESTERN MARGIN OR BRITISH TYPE

Climate

Valentia, in South-West Ireland, has been taken as an example of western margin conditions. The temperature

graph (Fig. 114) shows that there is little difference (range 15° F.) between summer and winter temperatures as compared with some of the examples that will be dealt with later. It should be noted, however, that Valentia has an exceptionally low range even for areas of this type. In Eastern England, for example, the annual range is over 20° F. The outstanding features of the climate of this region are its equability and the unusual warmth of the winters for the latitude. Winters

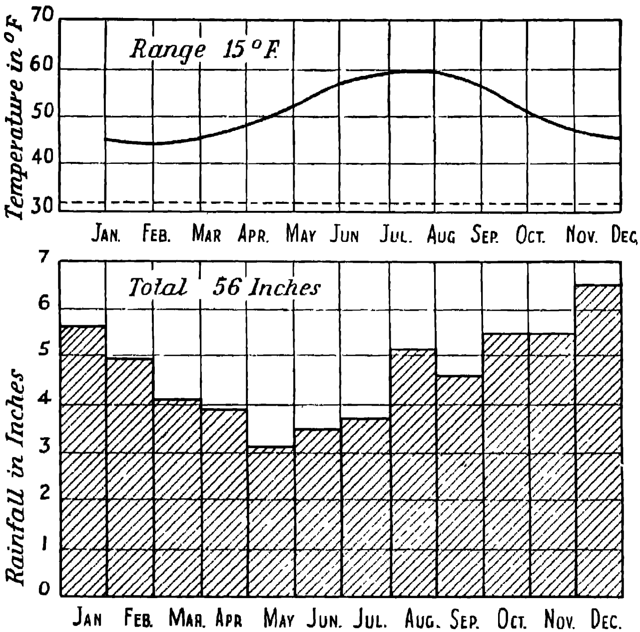


Fig. 114. British Type. Valentia (12 ft).

in these regions do not fall below freezing point, and in the north of Scotland, for instance, the winters are about 40° warmer than the average for the latitude. The mildness of the winters and the fact that the summers are not unduly hot (60° F.) is due to the prevalent westerly winds which, coming from the ocean, raise the temperature of the land in winter, and lower the summer temperature. The shores of these regions are washed by warm ocean currents, flowing

polewards, and these also help to raise the winter temperatures.

The westerly winds are also responsible for the rainfall. They blow all the year round, and therefore rain falls in every month, though generally there is more in winter than in summer (Fig. 114). The amount of rainfall varies. On high mountainous areas an annual fall of 200 in. may occur (*e.g.* Snowdon), while in sheltered regions the total rainfall may be as little as 20 in., as at Shoeburyness. The rainfall is increased by "depressions" which follow the track of the westerlies (see Chapter X).

The regions of the world having this type of climate are shown and named on Fig. 115.

Development

The development of forested areas often follows this sequence: (1) hunting and trapping of animals for their furs; (2) lumbering and the manufacture of wooden articles; (3) agriculture on the cleared land; (4) manufacturing, if some form of power is available, *i.e.* coal or water-power. Some of the temperate forest regions have reached the fourth stage, while others are still engaged principally in trapping, or lumbering.

The whole of this region in Europe was originally covered with forests, usually of the deciduous type, except where altitude or soil conditions encouraged the growth of coniferous forest. Most of this forest has now been cleared, but there are isolated patches in some of the mountainous areas, as in the north of Spain and the Vosges Mountains, while the Scandinavian peninsula still has large areas of forest land. The clearing of the trees and the gradual spread of agriculture and settlement in the cleared lands was a slow process. To-day, the development of North-West Europe has proceeded far beyond the primitive agricultural stage, for the discovery of minerals, and in particular coal, has led to the development of mining, industries, and commerce on a very large scale. Thus North-West Europe is very highly developed and contains areas of extremely dense population centred mainly on the coalfields. These are principally in Great Britain, North-East France, Belgium, the Ruhr Valley of Germany, and the Saar Basin. In North-West Europe,

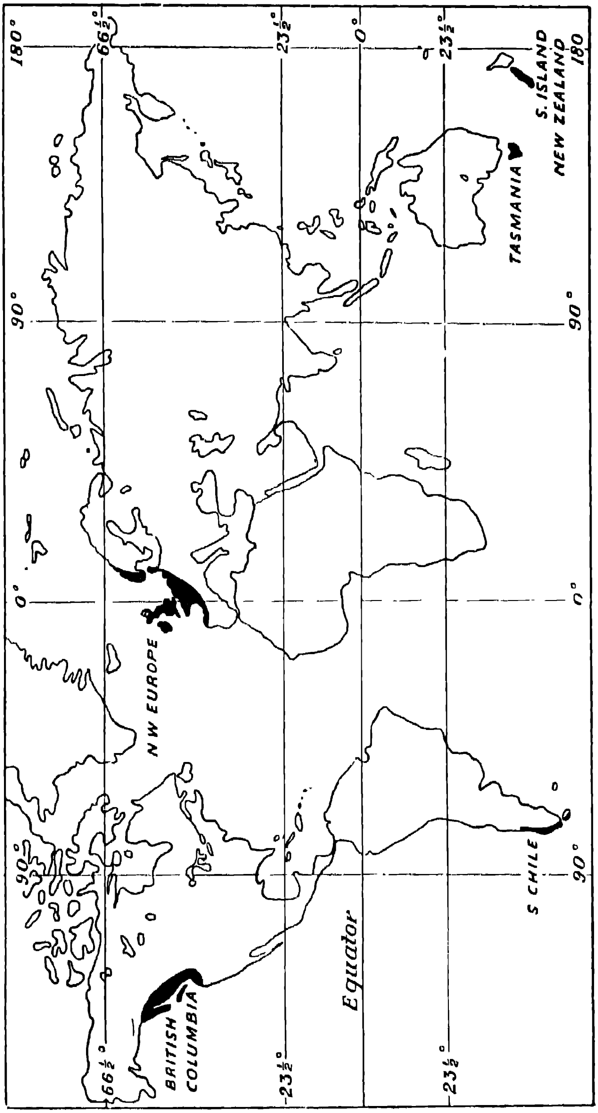


Fig. 115. AREAS WITH BRITISH TYPE OF CLIMATE.

agriculture is of the intensive type, *e.g.* by scientific methods the land is made to yield as great a return as possible. The other regions of this type are not yet fully developed, and in them there is as yet little industrial activity. In British Columbia lumbering is still important, but fishing, mining, and fruit growing are well developed. Tasmania and South Island, New Zealand, are mainly agricultural, but there are

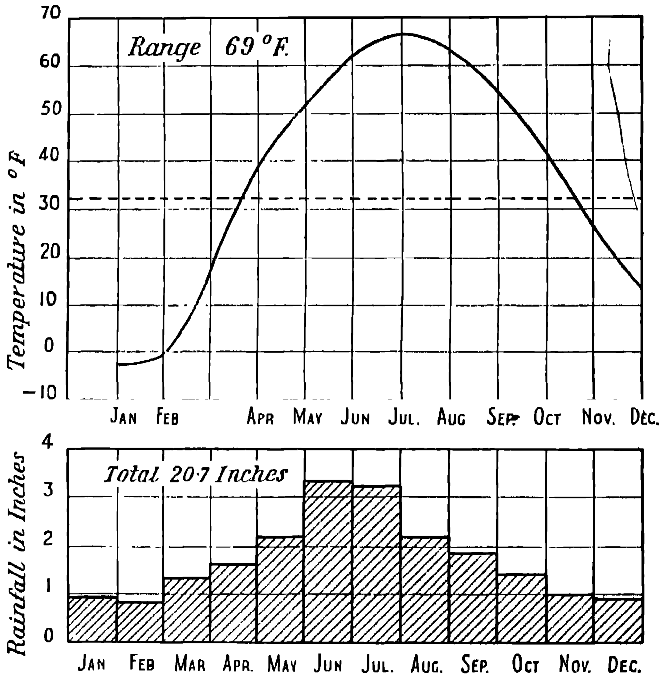


Fig. 116. SIBERIAN TYPE. WINNIPEG (786 FT).

vast tracts of uncleared forest. The south of Chile remains undeveloped, but offers great possibilities for lumbering, fishing, and dairying.

COOL TEMPERATE OR SIBERIAN TYPE

Climate

The climate of this type is one of extremes as a result of the distance from the sea. The summers are hot (approaching 70° F.), and the winters very cold (often below 0° F.). The

rainfall is light, averaging about 20 in., and it falls mainly in the spring and early summer. This rainfall is primarily convectional (see Chapter X). Winnipeg has been taken as an example to illustrate the climate of this type (Fig. 116). It is instructive to compare this temperature graph with that for Valentia (Fig. 114), and to notice that while the summer temperatures of these two examples are very similar, the graph for Winnipeg falls well below the freezing point in winter. See Fig. 117 for areas of the world with this type of climate.

Vegetation

The vegetation usually consists of unbroken stretches of coniferous forest or *taiga*, but in some parts local peculiarities of relief or winds and distance from the sea may reduce the rainfall and cause a poleward extension of the grass-lands into the forest belt, as in Alberta and Central Siberia. The principal trees of this forest belt are various species of pine, fir, spruce, and larch intermingled with birches, aspens, and other trees with broader leaves. The birch extends polewards beyond the limits of the conifers. The northern limit of tree growth is marked by the summer isotherm of 50° F. The coniferous forest belt has light rainfall and severe winters with strong winds, therefore the trees must store food. Their needle-shaped leaves provide the minimum of exposed leaf surface, and their conical shape makes for stability in strong winds. The trees have a large proportion of wood to leaf, and it is in the wood that food reserves are stored. There is little undergrowth in the coniferous forest. The ground freezes to a depth of 3 ft to 5 ft, and shallow-rooted plants would therefore perish. The accumulation of resinous pine needles and the prevailing darkness of the forest also limit the undergrowth. Over wide stretches of these forests there are only seven or eight kinds of trees, and sometimes over large areas trees of a single kind only are to be found. This makes lumbering easier, for this type of forest is one of the world's most important reserves of soft timber from coniferous trees—known commercially as "deal".

Stages of Development

As in the deciduous forest four stages of development can be traced: (1) trapping; (2) lumbering; (3) agriculture; (4) mining, if minerals exist.

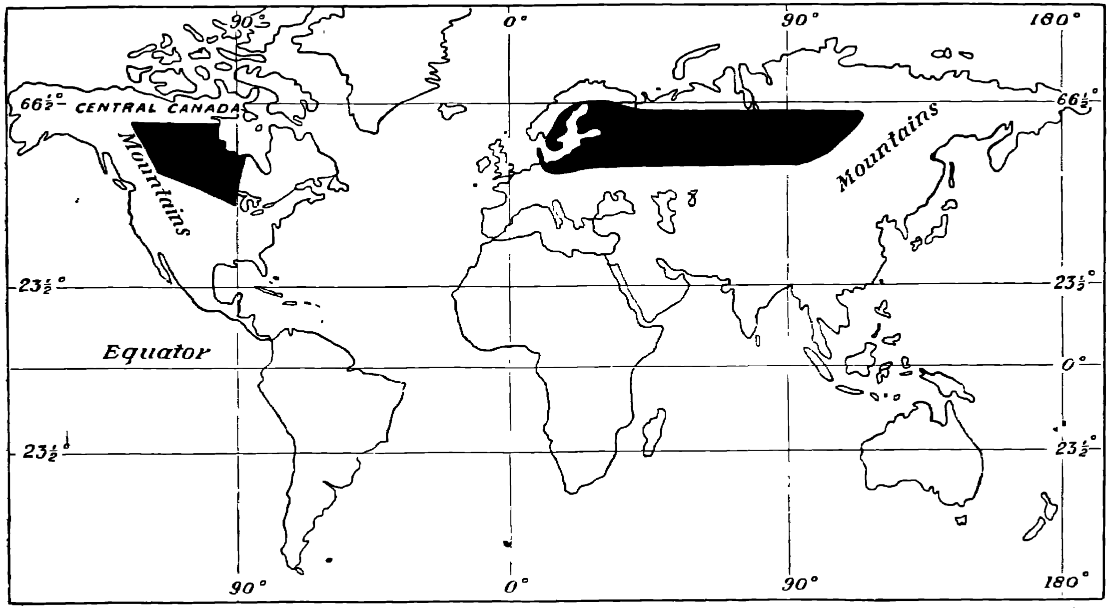


Fig. 117. Regions with Siberian Type of Climate.—1. Note that owing to the narrowness of the southern continents they have no areas with great extremes. 2. The area around the Baltic Sea may be considered as a transition zone between British and Siberian types, *i.e.* having ~~a~~ greater range than the former but not such a great range as the latter.

In the first stage trappers hunt animals such as the squirrel, fox, ermine, skunk, beaver, and marten for their valuable furs. Just as there are few types of trees in the coniferous forest, so the numerous fur-bearing animals which live within its depth are relatively few in species.

The severe winters, the frozen ground, and the snow covering make lumbering relatively simple. Agriculture has followed lumbering in the clearings, and minerals are known to exist in both the regions of this type.

There is, however, a great contrast in the development of Central Canada and of Central Siberia. This may be due to a number of causes briefly enumerated below:—

(1) There is, in Siberia, no great East-West waterway comparable with the St Lawrence and the Great Lakes, providing easy transport and leading to the busiest section of the Atlantic Ocean.

(2) The chief rivers of Siberia (Obi, Yenesei, and Lena) flow north into an ocean which is frozen for nine months of the year.

(3) Railway development in Siberia has been very much behind that of Central Canada.

(4) Central Canada has been settled and developed by the peoples of Western Europe, while Siberia, in the hands of an unprogressive Russia, was not exploited. This was partly due to its vast size, its isolation, the lack of capital, the presence of penal settlements, the political difficulties, and the greater attractiveness of other areas such as Central Canada.

(5) European settlers from countries other than Russia were not encouraged to settle in Siberia.

In recent years the U.S.S.R. has turned attention to the development of the Siberian lands, and there has been a rapid rise in agriculture (wheat production as in Canada), lumbering, mining, and manufactures.

Lumbering is an *exhaustive* industry, *i.e.* like mining and hunting, it results in a depletion of natural resources. For centuries, therefore, the world has been growing poorer in its resources of timber. The rate at which trees are removed during lumbering operations causes this industry to be transitory. When all the available timber of a region has been

cleared the lumbermen must move on. For this reason the dwellings are of a semi-permanent character (log-huts), and the life of the lumbermen is one of hardship and isolation. Only when a policy of re-afforestation and forest conservation is introduced can there be permanent settlements and a higher standard of living.

COOL, TEMPERATE EASTERN MARGIN OR LAURENTIAN TYPE

Climate

The climate of the eastern margin type (see Fig. 118 for the areas concerned) is neither so equable as that of the western margin, nor so extreme as that of the central zone. The difference lies mainly in the winter temperatures. It will be convenient at this point to compare the temperature graph for Quebec (Fig. 119) with those of Valentia (Fig. 114) and Winnipeg (Fig. 116). It will be noticed that there is not a great difference in the summer temperatures of these three places, but Valentia, open to the cooling effect of the Atlantic Ocean, has a lower summer temperature than the other two stations. In winter, however, Valentia has winter temperature above 32° F., Winnipeg below 0° F., while Quebec is between 0° F. and 32° F., viz. 10° F.

It should also be noted here that while the western margin type is open to westerly winds from the ocean at all seasons, central areas like Central Canada are never subject to the moderating influence of the sea. In the eastern margins the prevalent wind in winter comes from the west, but this means that it brings the cold influences from the centre of the continent. In summer, however, the eastern margins have easterly winds from the ocean. These tend to moderate the summer temperatures, and are responsible for the summer rainfall.

The rainfall of the eastern margin is moderate in amount, 20 to 40 in., *i.e.* less than in the western margin and more than in the central zones. Thus, in rainfall as well as temperature range, the eastern margin is intermediate between the western and central zones. The rain falls mainly in summer when the wind blows inland from the sea. This can be seen very clearly if the rainfall of Vladivostok in Eastern Asia is

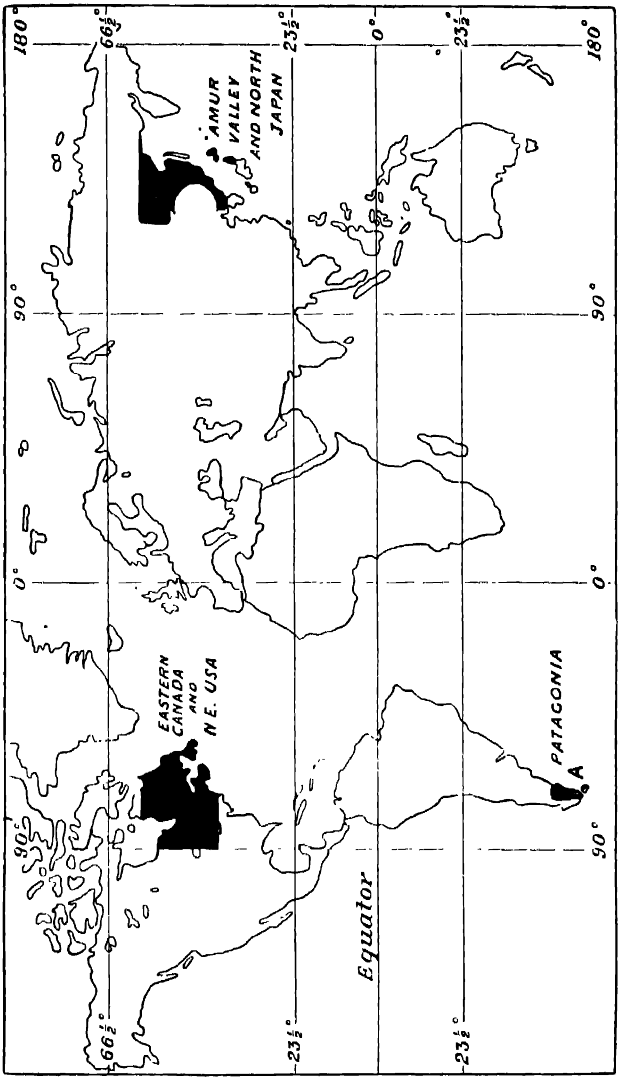


Fig. 118. Regions with Laurentian Climate.—See text *re* district (A) Patagonia, which is not true to type.

studied. But in Eastern Canada depressions are responsible for much winter precipitation (chiefly snow), and so the total rainfall is heavier and distributed more evenly throughout the year. The heavy winter snowfall of Eastern Canada is of great importance in relation to the lumbering industry.

One part of South America corresponds in position to this type, but it does not correspond in climate. This is the

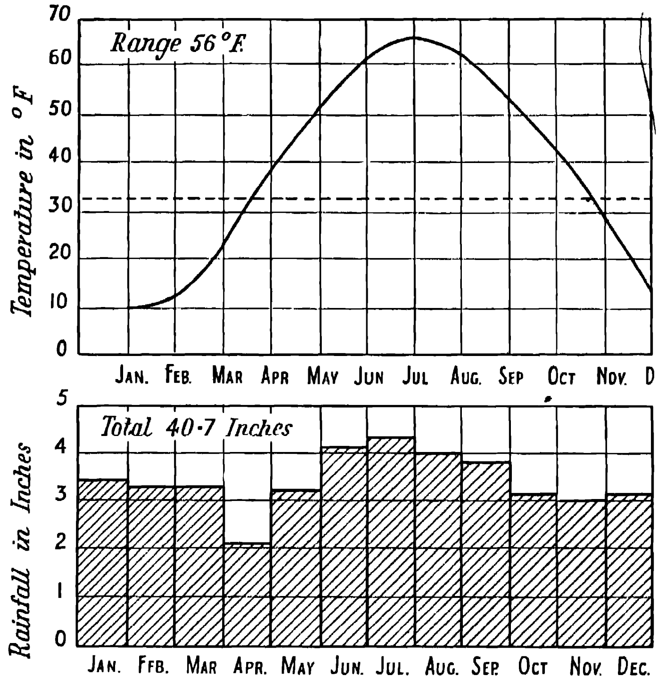


Fig. 119. LAURENTIAN TYPE. QUEBEC (296 FT).

southern section of Argentina, known as Patagonia. Here the continent is narrow, and the sea influence is stronger than in the eastern margin regions of the Northern Hemisphere. Hence the range of temperature is smaller and the winters much warmer. The mean July temperature is above 32° F., and not below 32° F. as is the January temperature in the Laurentian areas of the Northern Hemisphere. The Andes shelter this region from the westerly winds, and consequently

it has little rainfall (under 10 in.), so that it must be classed as a desert. Much of it is covered with scrub and poor pastures which are used for sheep rearing.

Vegetation

The vegetation is coniferous forest for the most part, and this type of region is part of the great forest belt of the cool temperate zone (Fig. 111). But in the extreme south-east of such regions, as in the St Lawrence Valley and New England in America, and Manchuria in Asia, deciduous trees flourish, *e.g.* the maple of Eastern Canada, and various kinds of oak, beech, etc., in Manchuria.

Development

The development of these regions should follow much the same plan as was noted for the Central Siberian type, viz. (1) trapping is followed by (2) lumbering and the development of industries resulting from large supplies of wood. When the land has been cleared of trees, (3) agriculture of some kind follows, where soil conditions permit. Later, the discovery of minerals may lead to the development of (4) mining and manufactures.

The east of Canada is at present more highly developed than the east of Asia, but the timber resources of Manchuria have been exploited to supply Japan with wood.

CHAPTER XV

NATURAL REGIONS—THE WARM TEMPERATE LANDS

Classification

According to the simple scheme outlined in Chapter XII, the warm temperate lands, excluding highlands, may be divided into:—

(1) Western Margin or Mediterranean type.

(2) Central or Steppe type.

(3) Eastern Margin or Chinese type (sometimes called Temperate Monsoon type).

The warm temperate belt lies roughly between latitudes 30° and 45°.

THE WESTERN MARGIN OR MEDITERRANEAN TYPE

Climate

All natural regions of this type (see Fig. 120) have a climate similar to that of most of the lands bordering the Mediterranean Sea. As stated in Chapter XII, the winds of these regions are wet westerlies from the ocean in winter, and dry trades from the land in summer. This general statement, however, will be subject to modifications when a more detailed study is undertaken.

The summers are hot, over 70° F., and over 80° F. away from the sea, as in Central South Italy. The winters are warm, averaging about 50° F. Rainfall comes mainly in the winter months and varies from 30 in. on the poleward side to 10 in. on the desert side. One area, that around Trieste, has over 80 in. annually. The poleward side of the Mediterranean areas usually has one summer month without rain, as in South France, but on the desert borders there may be as many as seven dry summer months, *e.g.* Tripoli.

The example taken as an illustration, Palermo, is on the island of Sicily, and is therefore centrally placed in the

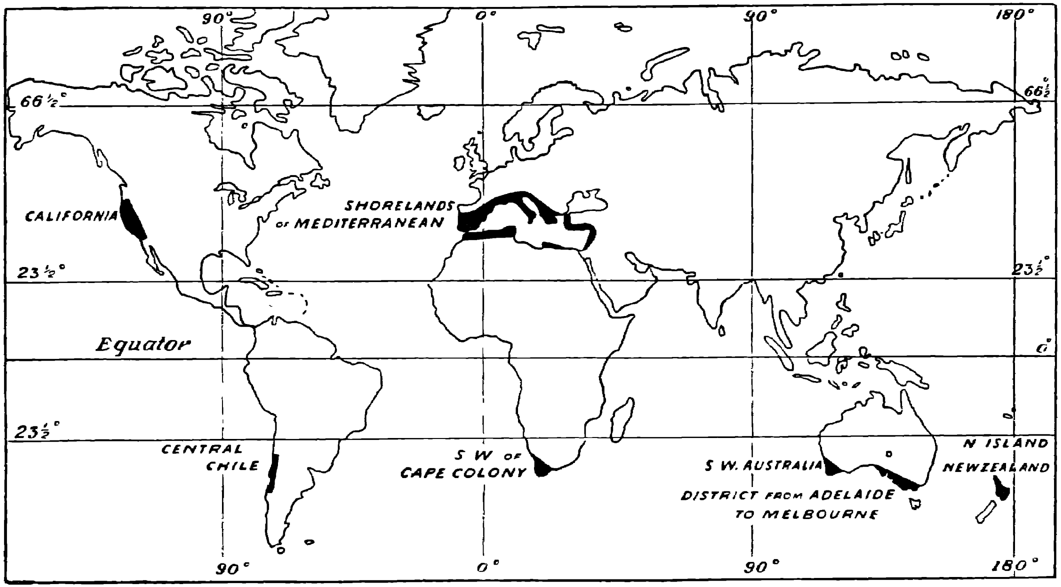


Fig. 120. Regions with Mediterranean Climate.

N.B.—The climate of North Island, New Zealand, is not exactly of the Mediterranean type, and some authorities classify it as a "British" type. Even on the shorelands of the Mediterranean Sea some places, *e.g.* Venice, are not typically "Mediterranean".

European Mediterranean area. It has three summer months when the rainfall is practically negligible. The range of temperature is from 77° F. in summer to 50° F. in winter, *i.e.* 27° F. (Fig. 121).

Vegetation

The vegetation of this type may be classed as broad-leaved evergreen forests, woods, and shrubs. During the mild, wet

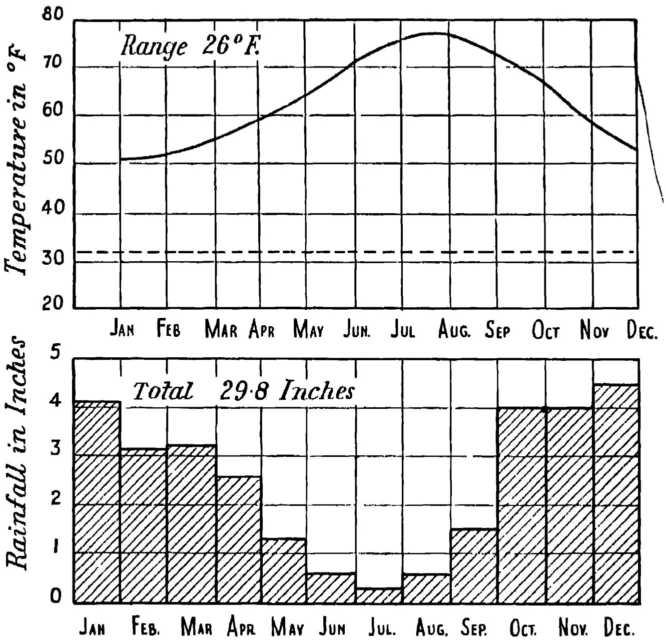


Fig. 121. MEDITERRANEAN TYPE. PALERMO (230 FT).

winters slow growth is possible. The summers, while not absolutely rainless, are dry so that in this season plant growth is again slow. Typical Mediterranean trees are adapted to this slow growth and to the summer drought by being compact and woody. Plants must protect themselves against excessive transpiration so that the evergreens have hard, small, and often glossy leaves, bluish and greyish-green in colour. Water-storing plants are also characteristic of these regions,

hence bulbous flowers are common, and also plants like the aloe, with thick sword-shaped leaves. The trees do not compare in size with the large woodland trees of the British Isles, and the absence of shade is a distinct feature of the Mediterranean lands. There is little green pasture comparable with English pastures, for the summer drought prevents the growth of rich green grass. Various types of vegetation may be identified, such as forests of cork oak, groves of fig trees and olive trees, and such shrubs as myrtle, laurel, oleander, etc. Where the original forest has been destroyed it is often replaced by bushy scrub, known in Corsica as maquis or macchia. The flowering plants of the maquis have earned for Corsica the name "The Scented Isle".

Cultivated plants include various cereals (wheat, barley, etc.), and a large variety of fruits, such as olives, figs, oranges, lemons, peaches, apricots, plums, grapes, pomegranates, and almonds, and other varieties of nuts. Of all these plants the *olive* is the most characteristic. In fact, it may be assumed that wherever olives grow the climate must be of the Mediterranean type, and that a map showing the distribution of olives will show the limits of true "Mediterranean" areas.

Development

Mediterranean regions do not pass through the same sequence of development as the cool temperate regions already discussed, though in the more recently developed regions outside Europe four stages of development may often be traced: (1) a search for precious metals, *e.g.* gold in California; (2) the rearing of animals for hides—meat products could not be exported before the introduction of refrigeration; (3) the growing of fruit; and (4) development of agricultural industries, viz. wine making, fruit drying, the extraction of olive oil, etc. While it is possible to trace most of these four stages of development in the Mediterranean areas beyond Europe, the development of the region around the Mediterranean shores goes back so far that it is not possible to trace the pioneer stages.

Forests are not extensive, and the wood of the trees has little value as timber, though some trees are of special importance, for example, the cedar for its wood, and the cork oak for its bark. The assured spell of fine, dry, sunny weather in

the summer has made these regions important for fruit growing and drying and for agriculture. The climate is ideal for wheat, particularly the hard varieties for the making of such products as macaroni. But the configuration of all Mediterranean regions is such that in none of them are there extensive plains comparable with those of Central Canada. Hence the Mediterranean regions are not, in spite of the good climate, the great wheat-producing areas of the world.

A survey of the "Mediterranean" regions shows that coal is rarely found, and never in large quantities. Hence large manufacturing and industrial areas comparable to those of North-Western Europe and the north-east of U.S.A. have not developed. Industries do exist in these regions, but they are for the most part the result of the abundance and variety of fruits, *e.g.* the manufacture of wine, olive oil, etc. Individual cities may have textile, engineering, and other industries (*viz.* Barcelona, Naples, Milan, Turin, and Marseilles), but they are not centres of great industrial areas as are Birmingham (Central England) or Düsseldorf (Ruhr Valley).

THE WARM, TEMPERATE CENTRAL LOWLAND OR STEPPE TYPE

Climate

The central areas of continents are far-removed from the sea, hence they are regions of great extremes of temperature. The summers are hot (over 80° F.), and the winters very cold (below 32° F.). The rainfall is light (about 20 in. annually), and falls mainly in the spring and early summer. This rainfall is of the convectional type (see Chapter X).

The example (Fig. 122) taken to illustrate this climate is Bismarck, a town in the state of North Dakota (U.S.A.). As it is 1,674 ft above sea-level the temperatures are reduced by about 5° F. Examples taken from the Asiatic steppe land have a very light rainfall (under 10 in.) because of the great distance from the sea. Graphs drawn for towns in the steppe lands of the Southern Hemisphere do not show the extremes of temperature typical of the steppe lands of the Northern Hemisphere. This is because southern continents are narrower in temperate latitudes and sea influence is nowhere completely absent. The range of temperature in the Southern

Hemisphere is greatest in Argentina, where it is about 30° F This is small compared with the ranges of 50° F. to 70° F. found in the northern steppe lands. Fig. 123 shows the steppe land areas of the world.

Vegetation

Steppe lands are grass-lands. These rolling plains extend as far as the eye can see, with nothing to break the dull

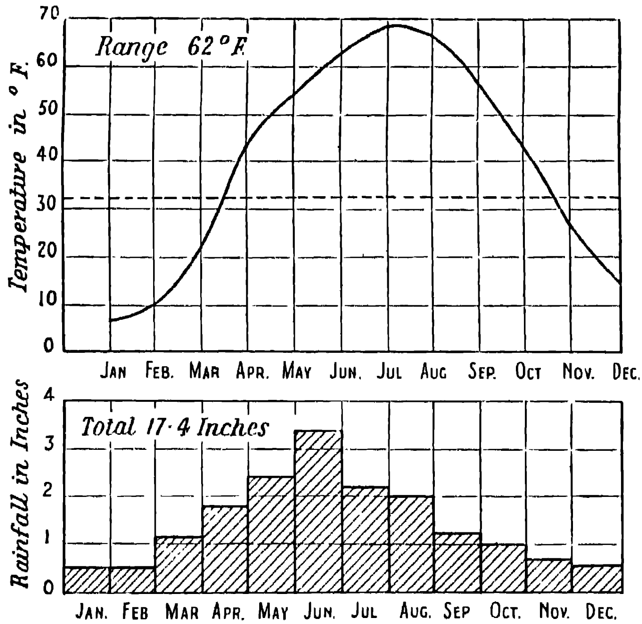


Fig. 122. STEPPE TYPE. BISMARCK (1,674 FT).

uniformity and monotony of the scene—not even a tree. The extreme cold and dryness of the winters coupled with the scanty rainfall and intense evaporation makes tree life impossible except along the water courses where willows, poplars, alder, etc., grow. The grass is not like that of our English meadows, green and juicy, but consists of stiff, hard, dryish grass with blades curling inwards and is often greyish-green in colour. In the Argentine pampa the grass often grows in tufts between which the bare soil is exposed.

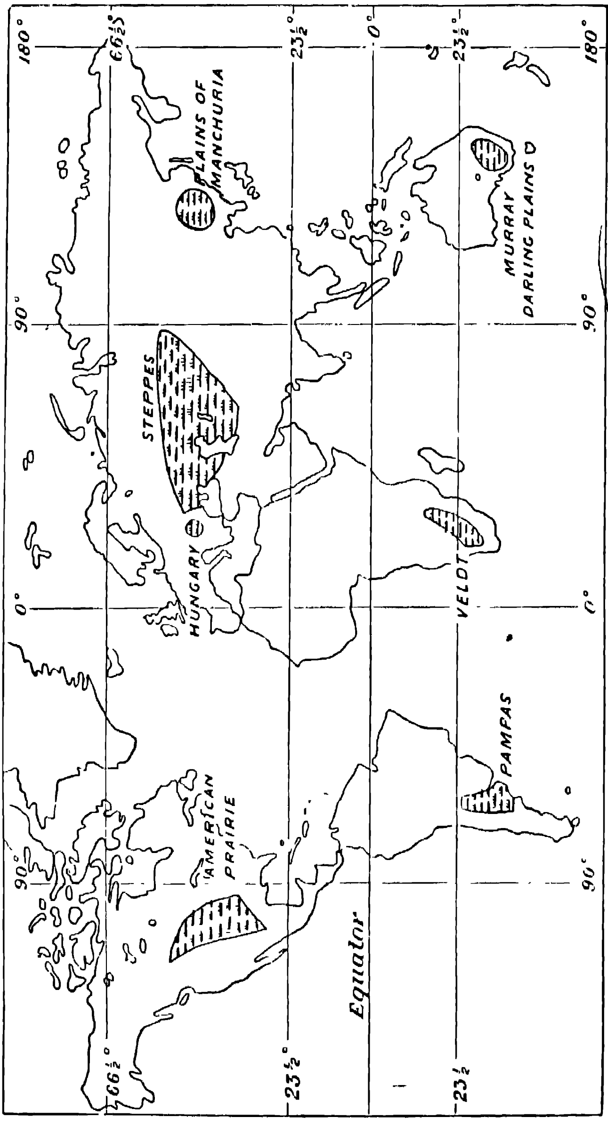


Fig. 123. Steppe Land Regions.

The appearance of the steppe varies with the season. In the early spring fresh green grass is bestrewn with the gay colours of myriads of flowers. Later in the year the grass becomes parched, dry, and brown as a result of the heat and drought. In autumn, in some steppe areas, a dry greyish-green vegetation may spring up which gives the steppe the appearance of a region of sage brush. In winter the steppe is bare and often snow-covered.

Where the rainfall approaches or exceeds 20 in. trees may occur, but where it diminishes to 10 in. the vegetation is poor scrub with thorny plants and the land becomes a semi-desert region.

Development

In steppe lands there are four phases of development:—

(1) The earliest stage is that of nomadism, the scanty population being hunters, constantly on the move in search of food. Later, if the animals native to the region are suitable for domestication, as in the plains of Eurasia, the nomads would be herders wandering over large areas in search of fresh herbage for their animals.

(2) The opening up of these plains by more advanced peoples leads to the rearing of animals by different methods, ranches and sheep runs with fixed homesteads taking the place of the pastoral nomadism and portable homes.

(3) In the damper and more fertile areas the steppes are ploughed and made to produce a wide range of temperate crops. Gradually the drier steppes, by means of irrigation and dry farming, are being cultivated.

(4) Industry is now spreading to the more advanced of these regions. The industries are of a specialised type. Just as the industries of the Mediterranean regions are related to fruit and other agricultural products, so the industries of the steppe land areas are based on the agricultural products and the animals that are reared. Such industries include the manufacture of cereal foods and starch; the canning of meat; the making of meat extracts; all forms of leather manufacture; bacon curing; refining of lard; and manufacturing of margarine, glue, and bone and horn articles. In some regions, notably the Central United States, coal underlies the surface

rocks, and this has helped to promote the industrial development.

A steppe land region does not necessarily pass through all these stages in succession, nor have all the steppe lands reached the same stage of development. In the steppes of Central Asia there are still large numbers of pastoral nomads, though the U.S.S.R. is rapidly developing the moister areas for agriculture. In America the damper prairies are used for grain growing and other agricultural pursuits, while the drier areas are great ranching lands.

The grass-lands of Australia are mainly used for sheep runs, while agricultural and stock rearing are both important, as also in the veld of South Africa.

WARM, TEMPERATE EASTERN MARGIN OR CHINA TYPE

Climate

This natural region (see Fig. 124) is sometimes referred to as the Temperate Monsoon type, for wet winds blow inland to the continental low pressure area in summer, and dry winds blow seawards from the continental high pressure area in winter (see Chapter XI). The summers are hot (80° F.), and the winters, being subject to cold winds from the land, are much colder than the winters of the western margin Mediterranean areas. The rainfall is moderate to heavy (30 in. to 50 in. annually), and falls all the year round with most in the summer half-year. These facts are illustrated by the graphs for Shanghai (Fig. 125). In the American area the winter rain is brought by depressions, and in the Asiatic area by the recurving of the out-blowing winds, back towards the coast.

Just as the Laurentian type (on the east side of a continent) has much colder winters than the British type (on the west side of a continent), so the China type (east side of continent) has much colder winters than the Mediterranean type (west side of continent). Lisbon and Peking (Peiping) are almost in the same latitude, but the River Tagus at Lisbon never freezes, while the River Pei-Ho at Peking freezes nearly every winter. It would be advantageous to make a comparative study of the Palermo and Shanghai graphs.

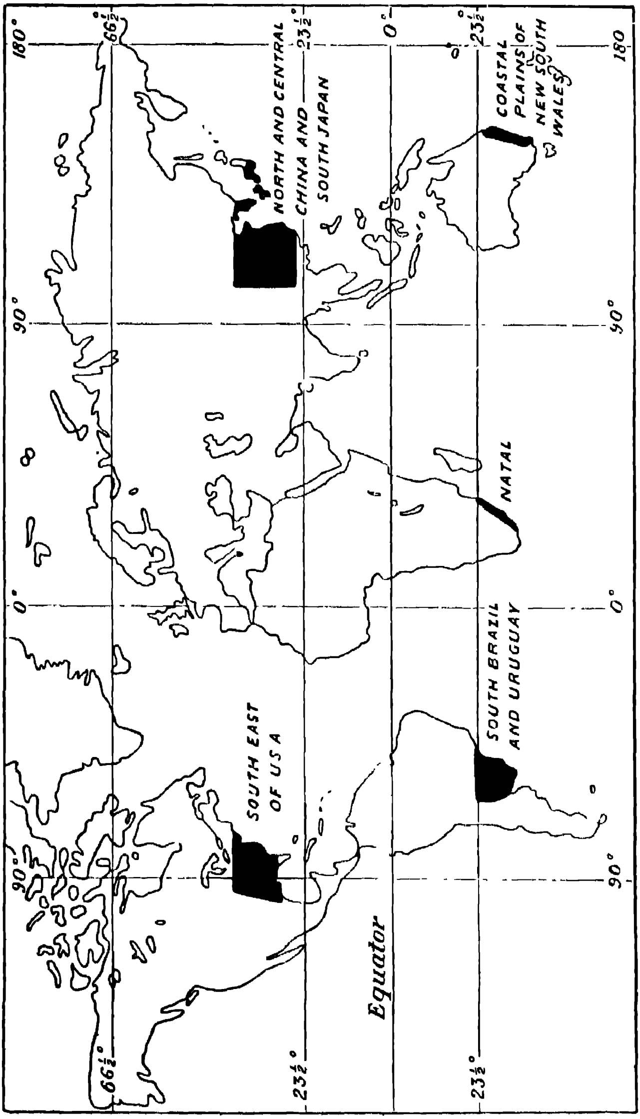


Fig. 124. REGIONS WITH CHINA TYPE CLIMATE, *i.e.* TEMPERATE MONSOON.

In the Southern Hemisphere the regions termed "China type" are somewhat different. They have a smaller range of temperature, the winter temperatures being raised by sea influence. There are no true monsoons, and the S.E. Trade Winds blow on-shore at all seasons, so that rain falls all the

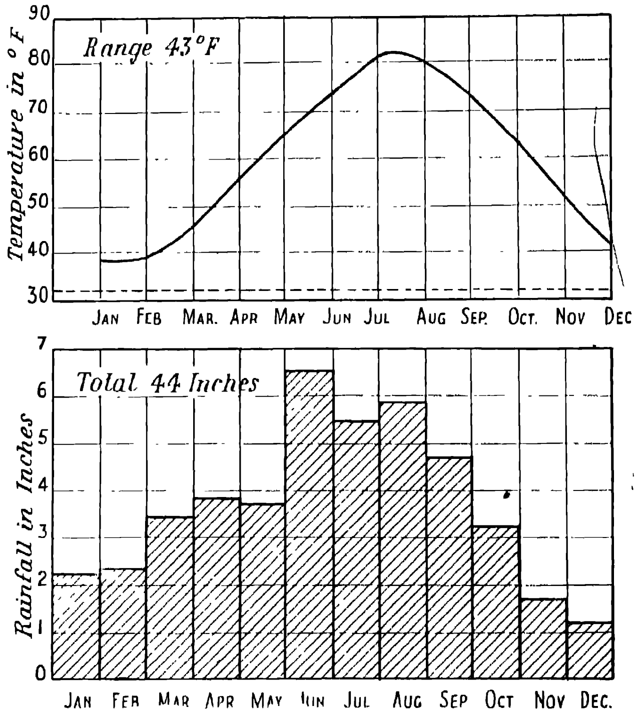


Fig. 125. China Type. Shanghai (33 ft).

year with most in summer, when the Trades blow more strongly towards the heated interiors of the continents.

Vegetation

The natural vegetation of these regions is a luxuriant type of deciduous forest on the lowlands, and conifers on the high land areas, as in the Appalachians, the Blue Mountains of Australia, the pine forests of Southern Brazil, and the Drakensburg Mountains in South Africa.

The forests include many types of trees similar to those of more northerly latitudes, *e.g.* beech and oak, and, in addition, magnolias, camelias, and camphor trees, etc. There are also tree ferns, small palms, bamboos, and a wealth of flowering shrubs. The variety and wealth of flowers and the denser undergrowth are the main differences between these forests and those of the cool temperate deciduous forests such as are found in Britain. Many of the trees and shrubs are important commercially: some for their timber, and others for camphor, tea, gum, etc.

Development

The development of that part of Asia which is of the "China" type dates so far back that it is difficult to trace any successive stages. In the other five regions colonisation is recent. These lands were, by nature, forested, and extensive forest areas still remain, particularly on the mountain slopes, *e.g.* the Blue Mountains in New South Wales. The lowland forests are composed of deciduous trees, and these must be cleared before agriculture can be practised. But lumbering has never become as important as in the St Lawrence area. The absence of snowy winters leads to increased difficulty in transport, and inability to compete with the lumber areas of the cooler latitudes. The wood of deciduous trees is "hard" wood, and for such there is a smaller market than for the softer and more easily worked wood of the conifers. In the south-east of U.S.A. much of the wood was cut and burned on the spot, an economic waste which was not realised until the treeless lands west of the Mississippi were opened up. Then the shortage of wood, the increased demand, and the consequent rise in prices led to a policy of careful conservation of timber reserves.

On the lands thus wastefully cleared a variety of crops have been grown, which vary according to the available labour supply and the nationality of the settlers in each district. For instance, in U.S.A., where there was abundant slave labour, cotton, tobacco, rice, and sugar are the principal crops. In Natal similar "hot" crops, *e.g.* sugar, rice, tea, pineapples, etc., can be grown, because the available labour supply includes not only native negroes, but Hindus and Chinese. In the South American region, which includes Uruguay and South

Brazil, the occupations are mainly pastoral, including the rearing of cattle, horses, and sheep, though the vine, sugar, maize, and bananas are being grown in limited areas, notably the hinterland of Porto Alegre. In the coast-lands of New South Wales there is no coloured population, and the agriculture is more "temperate" in type. Dairying and mixed agriculture occupy a large percentage of the land. Mediterranean fruits are grown, and "hot" crops such as sugar, are cultivated only in the extreme north of the region.

The development of industries in these regions, with the exception of Southern Japan, is still in its infancy. The latter district has, in recent years, made rapid strides as a manufacturing area. Manufacturing industries are now developing rapidly in the south-east of the United States, but in the remaining areas industries are comparatively few, and are for the most part based on agriculture, or else are branch factories of European firms often established to avoid import duties in the countries concerned.

CHAPTER XVI

NATURAL REGIONS—THE HOT LANDS

Classification

According to the scheme outlined in Chapter XII, the hot lands (roughly lying between 30° N. and 30° S.) can be divided into four natural regions:—

(1) Hot deserts, Sahara type.

(2) Savana grass-lands, Sudan type.

(3) Hot east coast:—

(*a*) Monsoon areas, Indian type.

(*b*) Trade Wind areas, Caribbean type.

(4) Equatorial areas, Amazon type.

HOT DESERTS

Climate

Hot deserts are found on the western margins of land masses, and lie, approximately, between latitudes 20° to 30°. The controlling factors in the climate of these regions are the high pressure belt (Horse Latitudes) and the drying Trade Winds, blowing off-shore. Thus rainfall is deficient, always under 10 in. annually, and in some places rain only falls once in five or six years. When rain does fall the showers are often torrential. The average annual rainfall of Iquique in South America, for instance, is 0·03 in. The coasts of all hot deserts are washed by cold currents flowing towards the equator. These reduce both the temperature and the rainfall. Because the sky is almost cloudless, night temperatures are very low, *i.e.* the diurnal range of temperature is large.

These climatic facts are illustrated by the graphs for Yuma (Fig. 126). Yuma is in the valley of the Colorado and near the boundary between the United States and Mexico.

The average July temperature in the deserts of the Northern Hemisphere is 90° F. and over, while the January temperatures average about 60° F. (*i.e.* as hot as the British summer). It is in the desert regions that the highest records

of temperature have been taken, *e.g.* 126° F. in the shade at Wadi Halfa. The summer temperatures of the desert zones are higher than the temperatures of the equatorial areas, where the temperature is reduced by clouds and rain. In the Southern Hemisphere such high readings are not recorded, owing to the greater influence of the ocean, and the smaller extent of the deserts, *e.g.* average summer temperatures in the Atacama Desert of North Chile range round 70° F. Fig. 127 shows the hot desert areas of the world.

Vegetation

Not all deserts consist of large stretches of loose sand. The best example of a sandy desert is the Igidi region south of

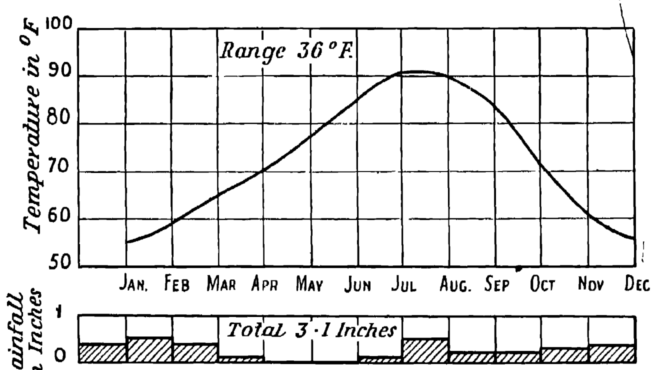


Fig. 126. DESERT TYPE. YUMA (141 FT).

Morocco, where sand dunes are often 600 ft high. In some cases the desert consists of dry baked clay, and in others of bare rock surface covered with broken rocks and boulders. (See plate facing page 224.) Desert zones are generally taken to include all areas with less than 10 in. of rainfall, and are therefore not entirely devoid of vegetation since 8 or 9 in. of rain will support a thorny scrub or rough pasture.

The desert vegetation consists entirely of plants that have to withstand long periods of drought. Thus there is, in America especially, an immense variety of cacti. Grass is of the tough, wiry variety, and there are numbers of small thorny bushes. In places where ground water comes near to the

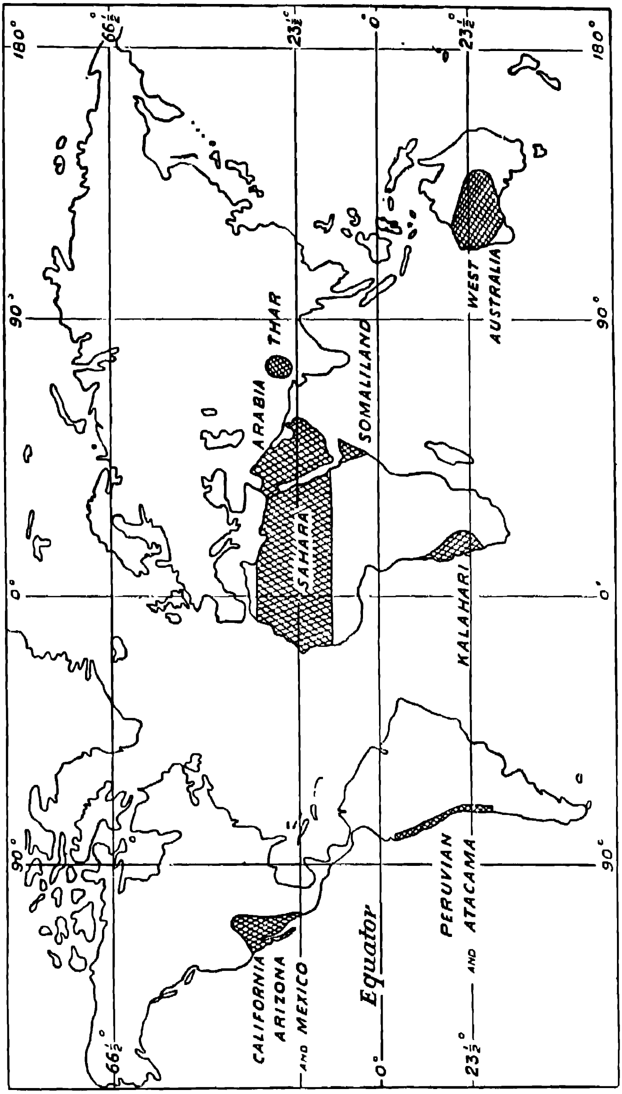


Fig. 127. The Hot Deserts.

surface there are oases, which show clearly how fertile the desert soil is when water is available. In these oases, date palms flourish, and a great variety of products can be grown, such as cotton, rice, sugar, vines, millet, tomatoes, tobacco, and fruits.

In a temperate desert, such as Chinese Turkestan, the oasis vegetation will be that of the temperate zone, viz. willows, etc. Oases are often very large, covering one hundred or more square miles (*e.g.* Tafilet), and supporting relatively large populations (*e.g.* Damascus).

Development

Desert regions, because of their low rainfall, are scantily populated areas where little development has taken place. The inhabitants of desert zones fall into three main categories: —

(*a*) Primitive peoples who have been driven to the poor scrub lands by stronger tribes, *e.g.* the Bushmen of the Kalahari. Such peoples are, by nature, hunters, for whom cultivation, settlement, and permanent homes are impossible.

(*b*) Cultivators who live in natural oases or other irrigated areas. Since the certainty of dry weather ensures successful harvests, and winter temperatures are high enough for the growth of temperate crops, cultivation reaches an advanced stage. The drier borderlands of the oases are utilised by pastoralists (often nomadic) who rear sheep, goats, and camels.

(*c*) Recent immigrants who, lured by minerals and the possibility of quickly acquired wealth, face the obvious privations due to scarcity of water. Elaborate schemes for the supply of water to such mining settlements have to be inaugurated. But mineral deposits are, in time, worked out, and the population disappears, since permanent agricultural settlement is not possible.

SAVANA GRASS-LANDS

Climate

These areas lie between the desert and the equatorial forest (Fig. 128). The summers are very hot (80° F. to 90° F.), and the winters are hot (70° F.). As these regions are within the tropics they are never cold, and the range of temperature is not great. The rain falls in the summer when the equatorial

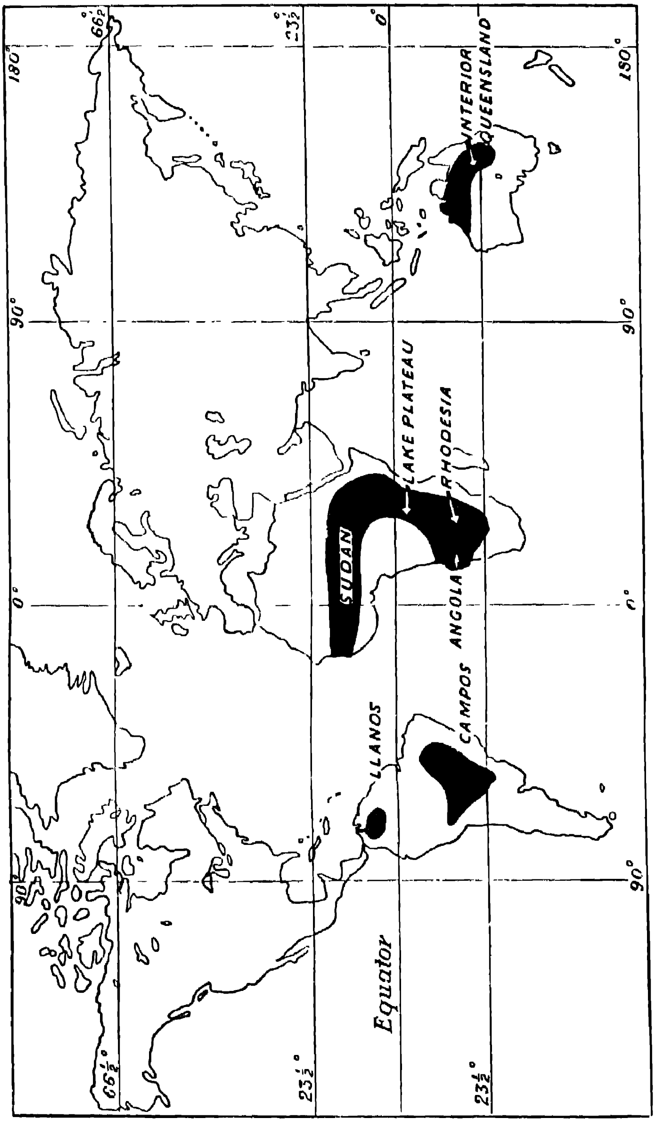


Fig. 128. Savana Regions.

belt of convectional rain moves north or south with the sun (see Chapter XII), and the winters are dry, for this is the season of the Trade Winds.

The climatic graphs typical of the savana region are those for Kayes, a town on the River Senegal in West Africa. Even the winters are very hot. The maximum temperatures occur early in the summer, in this instance in May. This seems

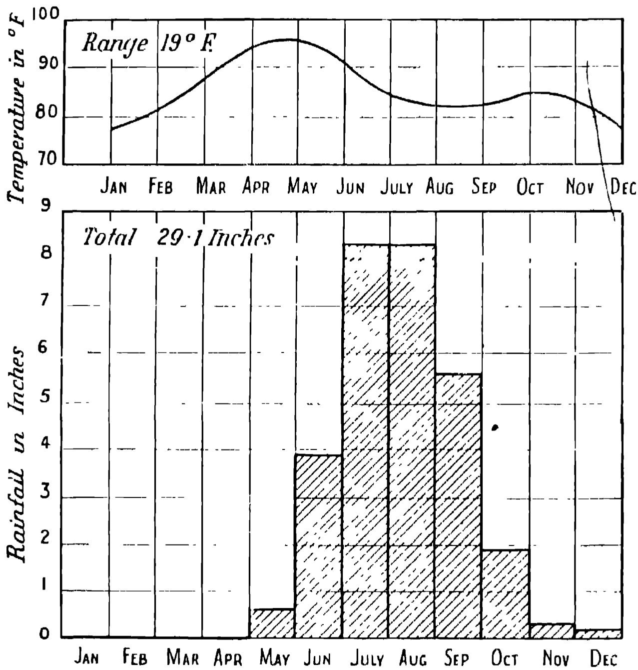


Fig. 129. Savana Type. Kayes (197 ft).

strange, for in all the graphs used hitherto the hottest month has always been July or August. If one compares the rainfall graph with the temperature graph the explanation of the drop in temperature in June, July, and August will be clear. In these months it is raining heavily and the sky is overcast. Thus the power of the sun's rays is reduced and the temperature falls. This same temperature feature will be noted in the monsoon areas, for temperatures in India fall after the monsoon

PLATE 21

Above. Stony Desert—Sinai. (*Picture Post.*)

Below: Sandy Desert—Death Valley, California. (*U.S. Information Se

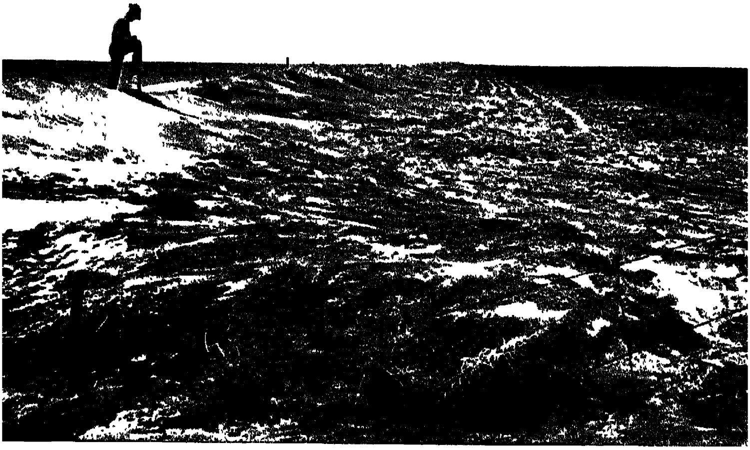


PLATE 22

Above. High winds, following a long dry spell, have destroyed these wheat fields in California, by blowing away the powdery top-soil. (*U.S. Information Service.*)

Below: Agricultural land in New Mexico, reclaimed from desert by irrigation. (*U.S. Information Service.*)

"breaks". In the savana regions, also, the sun is overhead twice during the year, once between March and June, and once between June and September.

Vegetation

The vegetation is grass-land dotted with clumps of trees, and is often termed "parkland". Actually the vegetation varies considerably from the desert margins to the forest margins. Near the desert the grass is poor, and there are scattered thorn bushes. The grass becomes richer and trees more frequent as the forest is approached, until, finally, there are large woodland tracts, with intervening grassy areas.

Although the savana is a grass-land, it does not resemble either the English meadows or the temperate steppes. The grass often grows 5 to 10 ft high, and has a dry appearance. In some districts impenetrable elephant grass reaches a height of 12 to 15 ft.

Development

True savanas are only found in the southern continents, and all are south of the Tropic of Cancer. Thus they are situated, not in the areas of long development, but in the more recently discovered and still undeveloped parts of the world. At first sight it would seem that since savana lands are grass-lands they would follow a sequence of development similar to that of the steppe lands, viz. pastoral nomadism, settled agriculture, and agricultural industries.

The nearest approach to this sequence of development is to be seen in Africa. Many of the negro tribes throughout the grass-lands of Africa are nomadic herders of cattle. Some of the negroes, *e.g.* the Hausas of Nigeria, have passed beyond this stage and are primitive cultivators. With European penetration more modern methods of culture have been introduced, and natives are encouraged to produce more than they need so that there is a surplus for export.

In the savanas of South America and Australia conditions were not favourable for the development of pastoral nomadism. The grass-lands of South America had no indigenous hoofed animals suitable for domestication. These savanas were inhabited by various types of rodents such as the chinchilla, viscacha, and capybara, animals belonging to

the same family as rabbits and hares. The Australian grasslands were the natural home of animals called marsupials, of which the kangaroo is an example. In these lands, therefore, herding was not a possible occupation until the introduction of cattle, sheep, horses, etc., by Europeans. The native peoples of the Australian savana are the "Black fellows", a primitive group comparable in development to the Bushmen of the Kalahari Desert.

None of the savana areas is highly developed as yet, but they hold great promise for the future. As they are never cold, crops can be grown all the year round, hence they should, in the future, yield temperate crops in the winter season with irrigation, if necessary, and tropical crops during the summer season. Thus they have great possibilities for the extension of cotton cultivation, and the production of tobacco is steadily increasing in Rhodesia.

HOT, EAST COAST TYPES—A. MONSOON OR INDIAN TYPE

The hot east coast lands (Fig. 130) fall naturally into two groups:—

(*a*) Monsoon or Indian type;

(*b*) Trade Wind or Caribbean type.

Climate

In the true monsoon lands (*i.e.* Indian type) the winds are seasonal. Wet on-shore winds (*i.e.* winds from the sea) are prevalent in summer, and dry off-shore winds (*i.e.* from the land) blow in winter. The winds of India are therefore south-west in summer and north-east in winter.

True monsoon lands are very hot in summer (approximately 80° F. to 90° F.), and warm to hot in winter. The rain falls in summer when the winds are blowing on-shore, but the total annual rainfall varies according to the locality, being heaviest where the mountains are favourably situated in relation to the direction of the prevailing winds, *e.g.* on the West Ghats and in Burma and Assam. But in North-West India there is an arid zone (the Thar Desert) with less than 10 in. of rain

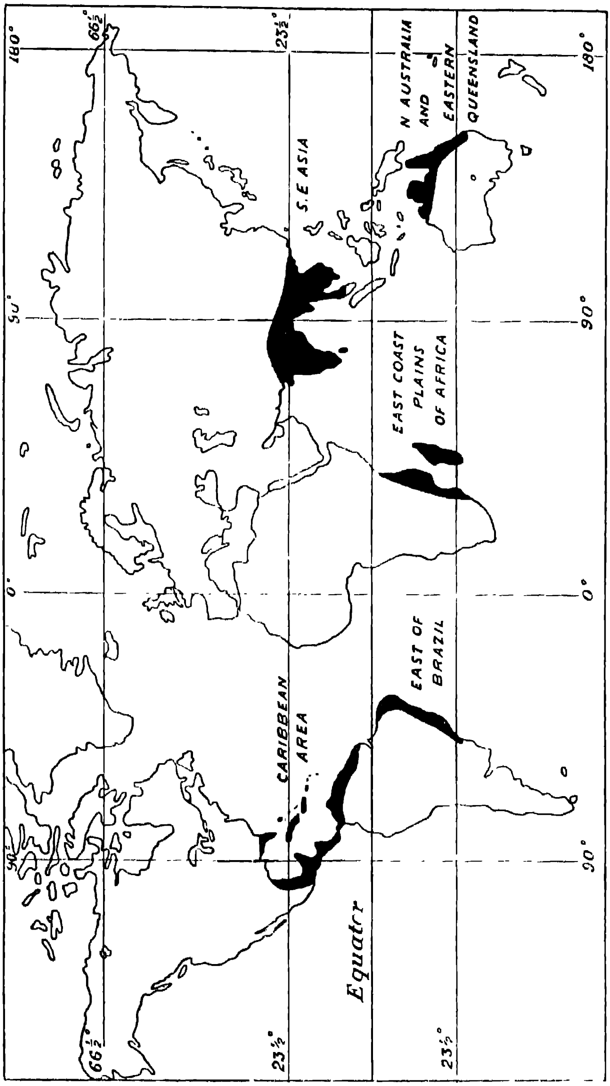


Fig. 130. Monsoon Regions and Hot East Coast Regions

annually. In true monsoon areas the year can be divided into three seasons:—

(1) October to March, the cool, dry season.

(2) March to June, the hot, dry season.

(3) June to October, the hot, wet season.

The rains come very suddenly, and there is then a drop in temperature similar to that noted in the savana areas. Thus the hottest month is usually April or May in the Northern Hemisphere. These divisions of the year can be worked out by a study of Fig. 131.

The rainfall of the districts around Madras comes in the late autumn and winter, under the influence of the north-east wind which has crossed the Bay of Bengal. There are really only two true monsoon areas in the world, viz. South-East Asia and North Australia, though East Africa receives the "fringes" of the Indian Ocean monsoon system. The Asiatic and Australian monsoons are complementary to one another. In July (winter in Australia) a dry land (S.E.) wind blows off-shore, and crossing the equator becomes a wet S.W. wind blowing on-shore in Asia (where July is a summer month). In January (Asiatic winter) a dry land wind (N.E.) blows off-shore, and crossing the equator becomes a wet N.W. wind blowing on-shore in Northern Australia [where January is a summer month (see Fig. 105)].

Vegetation

The vegetation of the monsoon areas varies with the amount of rainfall. Where the rain is very heavy (over 80 in.) there are "rain forests" which are always green; heavy rain (40 to 80 in.) produces a rich, deciduous forest (teak, etc.), which sheds its leaves in the dry, hot season; moderate rainfall only supports a kind of grass-land and thorn scrub, while in areas of deficient rain there is desert, *e.g.* the Thar Desert.

HOT EAST COAST TYPES—B. TRADE WIND OR CARIBBEAN TYPE

Climate

There are, however, other regions in the world, where the temperature and rainfall conditions are very similar to those

of monsoon areas. The winter temperatures are 70° F. or over and the summer temperatures over 80° F. (Kingston, Jamaica, January 75° F., July 82° F.). The rainfall is over 40 in., but its yearly distribution differs from that of the true monsoon areas. Instead of there being definite wet and dry seasons as in India, the rainfall is more evenly distributed throughout the year, though in all cases there is a pronounced summer maximum. This is because the winds are not seasonal as in true monsoon areas, but the Trade Winds blow on-shore all the year round. They blow most directly on-shore and are strongest in the summer months, hence the increase in the summer rainfall. Trade Winds pick up moisture greedily as they cross the warm oceans, and thus when they reach high land and are forced to rise, they cause heavy rainfall. Note, however, that Trade Winds are not in general wet winds unless they are forced to rise (see page 181).

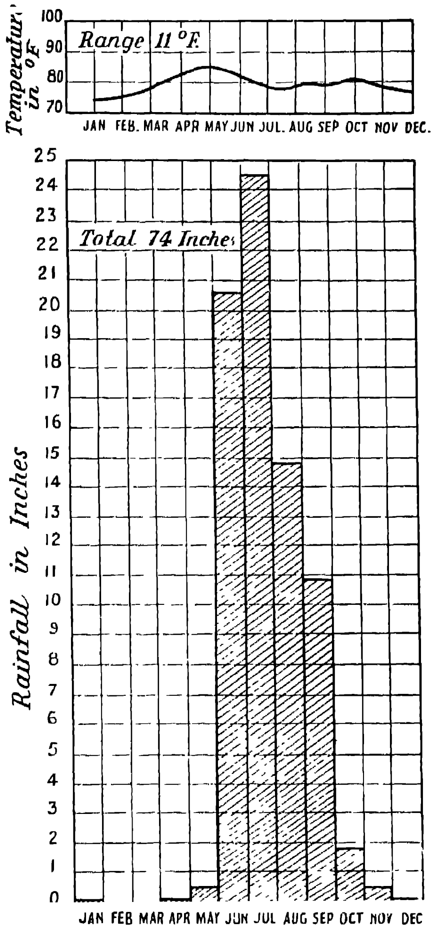


Fig. 131. MONSOON TYPE. BOMBAY (37 FT).

Vegetation

Because the temperatures and total rainfall of the Caribbean type are so similar to those of the monsoon areas, the natural vegetation is a luxuriant forest, comparable with the forests of South-East Asia. When cultivated, both types of region yield similar products.

Development

In regions of the monsoon or Caribbean types where the original forest still remains uncleared the lumbering of hardwoods is of some importance. Teak is the most noted timber of South-East Asia, especially in Burma and Siam. Transport of the logs is not as easy as it is in the temperate regions where the ground is frozen in winter, hence elephants are used for hauling the timber.

When the forests have been cleared, the people are engaged in tropical agriculture, growing some of the following crops:—rice, millet, cotton, coffee, jute, sugar, hemp, bananas, pineapples, etc.

The high temperatures, heavy rainfall, and humid atmosphere make white labour impossible in the hot east coast regions. Hence their development is dependent on coloured peoples who can work in such climates, and white people are generally engaged in the work of organisation. The Hindu and Chinese immigrants of East Africa, the Negro immigrants of the West Indies, and Hindus in British Guiana make agricultural development possible in the areas named. In some regions such as South-Eastern Brazil, the people of South Europe, *e.g.* Italians and Spaniards, work on the plantations.

Tropical agriculture reaches its most advanced stage in South-Eastern Asia. The land is cultivated so carefully and with such diligence that the small "farms" (often not more than two acres) are highly productive. No land is wasted, and the hill sides are terraced to provide more available farm land. The methods used are more like those of gardening than farming, hence the frequent application of the term "horticulture" or "spade agriculture" to the type of cultivation practised in monsoon lands. Because of this intensive culture and the growth of more than one crop per annum, the

plains of South-East Asia support an extremely dense population.

In all the other regions of the hot east coast type (except Northern Australia), the development of plantations by Europeans for the large-scale production of crops is carried on side by side with native agriculture. The degree of progress depends largely on the available labour supply.

Thus in the West Indies, where there is negro labour, plantations are extensive, but in North Australia, where coloured labour is excluded, the land is still undeveloped. There is little industrial development, and the main function of these regions, at present, is (1) to yield supplies of foodstuffs and raw materials for the densely populated industrial areas of the temperate zone; and (2) to provide a market for the manufactured goods of those areas.

EQUATORIAL AREAS

Climate

The temperature of these regions (Fig. 132) varies little from 80° F. all the year round, so that the range of temperature is very small. Rain falls throughout the year, but there are two periods of heavy rainfall, viz. soon after the equinoxes (March and September), following the passage of the overhead sun. These are also the slightly hotter periods. The four seasons of the temperate zone are unknown, for it is always hot and wet. Rain of the thunderstorm type falls on most days of the year, usually in the afternoon. The days are always 12 hours and the nights 12 hours, so that the sun rises at 6 a.m. and sets at 6 p.m. every day. Dawn and twilight are of short duration.

The town taken to illustrate these conditions is Yaunde in the Cameroons (Fig. 133). As it is 2,461 ft above sea-level, a dotted line has been inserted to show what the temperature curve would be if the temperatures were reduced to sea-level. The rainfall graph clearly shows the rise in the rainfall just after the sun has crossed the equator in March and September. Note carefully the range of temperature—the difference between the temperature of the hottest and coldest months, is only 4° F.

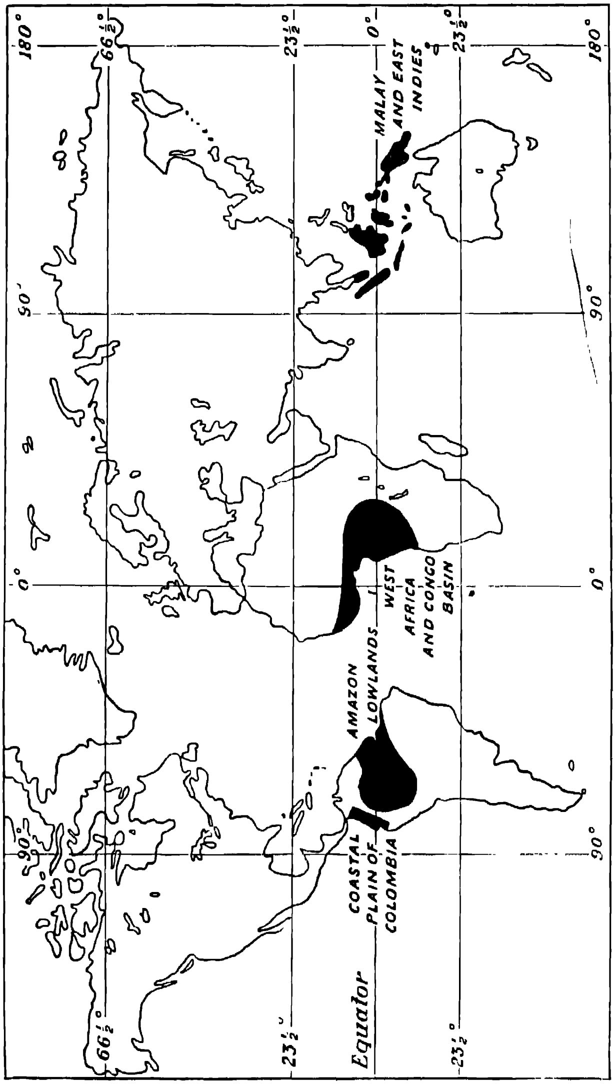


Fig. 132. Equatorial Regions.

Vegetation

The vegetation is forest, called *selvas*. This forest always looks green, for though many of the trees are deciduous, they do not all shed their leaves at the same time, as there is no marked seasonal rhythm in the climate. Thus it is possible to see one tree in full leaf, one devoid of leaves, one bearing

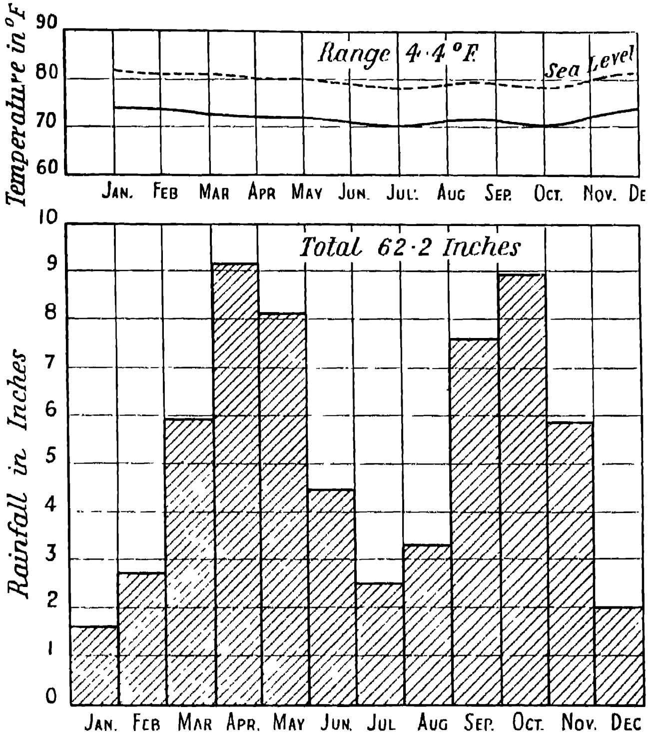


FIG. 133. EQUATORIAL TYPE. YAUNDE (2,461 FT).

fruit, and another bearing flowers all within a short distance of one another. Another characteristic of this forest is the great variety of trees. In the temperate coniferous forest the same kind of trees may grow for mile after mile, but in the equatorial forest there may be only two specimens of the same tree on an acre of ground. Among the important trees

are mahogany, rosewood, ironwood, greenheart, and the rubber and cacao trees.

The true selva has a closely interlocked canopy formed by the crowns of the trees. This shuts out the light from the lower part of the forest, which is, as a result, dark, damp, and gloomy, with little undergrowth. Giant lianes or vines twine from tree to tree, and some hang from the branches and coil in great tangles on the ground. Where the forest canopy is less compact and sunlight can penetrate, dense undergrowth develops. Many of the animals of this forest live most of their lives in the trees. These forest areas are not easy to clear, and when cleared, weeds and small bushes grow with amazing rapidity.

Development

As these are forested regions, it would not be unreasonable to expect that the successive stages of development would be similar to those of the forest regions of the temperate zone, viz. hunting, lumbering, agriculture, and industry. But owing to the nature of the forests, the type of wood, and the climatic conditions, these stages of development have not occurred, and the forest has only been cleared for cultivation in the most favourable and most accessible districts.

The animals of the hot forests, though many and varied, are not fur-bearing, since they do not have to withstand the cold temperatures of the northern winters. Hence trapping has never been important, though native tribes hunt some of these animals for their flesh.

Extensive lumbering operations comparable to those of the temperate forests have been impossible for a number of reasons:—

(*a*) There are no cold winters and no heavy snow-fall to provide a frozen surface over which the logs can be hauled easily.

(*b*) The ground is soft and wet, and transport correspondingly difficult.

(*c*) Although there are numerous large rivers on which logs can be floated, many of the woods of the equatorial forests are heavier than water, and have to be transported by boat.

(*d*) The trees do not grow in "stands", and the work of finding and then extricating the suitable trees is laborious and expensive.

(*e*) Although many of the trees yield valuable and beautiful timber, highly prized for cabinet work, there is not as large a demand for these woods as for the softer and more easily worked timber of the temperate forests. For this latter reason one often finds a settler in the Amazon Valley using imported North American timber for building purposes, in spite of the fact that forests are growing all around him. Lumbering is a very heavy form of manual labour, and therefore is an unsuitable occupation for white people in hot, damp climates. The native peoples are generally few in number, and are not adapted to organised work such as lumbering entails.

Agriculture is not possible until the forests have been cleared, and even when the clearings have been made the problem of coping with the growth of weeds is a difficult one. Thus, in the equatorial regions, with the outstanding exceptions of Java and Malay, the development of plantations has not progressed very rapidly. The greatest need is that of a labour supply, and the future development of the equatorial areas depends largely on the recruiting of coloured labour, since it is obvious that the regions are unsuitable for white labour.

The native peoples of the equatorial forests are not numerous, and they are, for the most part, hunting tribes who seek both animal and vegetable food in the forest. Some of the tribes practise a little primitive agriculture, and grow a few bananas, or a small patch of roots such as yams or cassava (manioc). Since it is always hot and wet and plants grow very easily, a small expenditure of energy results in a certain and abundant crop. Thus these native peoples do not realise the need for steady organised work for the production of crops for export, and so are not a reliable source of labour. (See also p. 245.)

CHAPTER XVII

PRIMITIVE COMMUNITIES

Introductory

The preceding chapters on Natural Regions have shown that all parts of the world, even those with similar conditions of climate and vegetation, have not reached the same stage of development. The more civilised man has become, the more he is able to utilise and develop the natural resources of the region in which he lives. But man is no longer limited to the same extent by his environment. He can overcome many natural disadvantages such as the lack of water by irrigation schemes, marshy land by drainage, and the prevalence of disease by medical knowledge, etc. He no longer relies entirely on local supplies of food and raw materials, but, through the development of trade and commerce, has access to the vast resources of the whole world.

There are still, however, immense areas which are undeveloped and where the inhabitants are almost entirely dependent on local resources. The peoples of these regions are often referred to as "Primitive Peoples".

The best known examples of such communities are to be found in the cold deserts, the Asiatic steppes, the hot deserts, the savana lands, and the equatorial forest areas.

The Cold Deserts

The two extensive regions of cold deserts are the tundra of Eurasia and the "Barren Lands" of North America.

THE TUNDRA OF EURASIA.—The chief groups of people inhabiting the Eurasian tundra are the Lapps, Samoyeds, and Yakuts.

The natural resources of these lands include the wild animals, birds, fish, and a variety of berries which ripen during the short summer. The vegetation consists of lichens, mosses, and berry-bearing bushes. Trees are limited to stunted birch and willow found along the water-courses. Animal life includes the Arctic fox, the Arctic hare, the lemming (a small mouse-like animal), the ptarmigan and other edible birds, and

the seals and walrus of the coastal regions. By far the most important animal is, however, the reindeer, which has been domesticated and which constitutes the chief source of wealth, and provides most of the necessities of life.

Because of the low temperatures, short summers, and frozen soil, agriculture is impossible, and the natural occupations are hunting, fishing, and herding.

The food of these peoples consists of flesh (often raw or decomposed), reindeer milk, and fish and berries, both of which are eaten fresh during the summer, but are also dried for winter use. By bartering furs and skins they sometimes obtain such luxuries as tea, coffee, and tobacco.

In these cold regions warm clothing is necessary, and is made from the skins of wild animals and reindeer. These skins are cured and made into garments by the women, who use bone needles and sinews for thread. Both men and women wear furry hoods over their heads, fur gloves, and long fur-lined boots.

As the reindeer, which live on mosses and lichens, must be constantly moved to new feeding grounds, the life is nomadic, and permanent homes are of little use. The tundra dwellers therefore live in tents (chooms) composed of a wooden framework over which are stretched reindeer and other skins. These can be easily transported from place to place. The floor of the tent is often carpeted with dry moss, but the only "furniture" consists of reindeer skins for beds, a cooking pot, and crude lamps in which seal oil is used for lighting during the long dark winter. Their other possessions include axes, and bows and arrows for hunting, though the use of firearms is increasing. For transport they use sledges, usually drawn by reindeer, and skis.

In the Southern Hemisphere the Onas of Tierra del Fuego live in a rather similar environment, and though of an entirely different race, have very much the same mode of life, depending for most of their necessities on the guanaco, an animal similar to the llama of the Andes.

THE "BARREN LANDS" OF NORTH AMERICA.—The Arctic regions of North America, and the coastal fringes of Greenland are inhabited by Eskimos.

The natural resources are almost identical to those of the Eurasian tundra, with one important exception, viz. that the

place of the domesticated reindeer is taken by the undomesticated caribou.

Therefore, the Eskimos are engaged almost exclusively in hunting and fishing, except where, in recent years, herds of reindeer have been introduced. Many of the Eskimo tribes are entirely dependent on sea fishing, and the hunting of whales, seals, and walrus. Even during the winter they will sit patiently for hours by a hole in the ice ready to spear fish with their harpoons. They eat fish and large quantities of fat or blubber in order to resist the cold. Vegetable food plays little part in their diet.

Their clothing consists of warm furry skin garments, *e.g.* seal skins and the skins of polar bears. For the winter they build snow huts (igloos) with windows of fresh-water ice, but in summer when the snow melts, their dwellings are tents made of driftwood and deerskins.

The summer, with its continuous daylight, is a period of activity, for then the caribou of the forest move north, and provide fresh quarry for the Eskimo hunter, while fish must be caught and dried, and blubber stored for winter use.

For transport they use canoes (kayaks), large boats (umiyaks) in which the whole family can travel, and sledges drawn by teams of sturdy dogs.

Most of their possessions such as harpoons, bows and arrows, sledges, etc., are fashioned from driftwood, whalebone, skins, and fishbones. In spite of their hardiness and ingenuity the Eskimos are barely able to maintain a livelihood, and their numbers are decreasing.

The Taiga or Coniferous Forest

South of the cold deserts a wide belt of taiga or coniferous forest extends from west to east across North America and Eurasia. The Ostiaks and Tunguses live in the Asiatic forest, and in former times the Red Indians, most of whom now live in government reserves, inhabited the American forest.

Because of the continuous tree covering, both agriculture and herding are equally impossible, and the forest peoples are primarily hunters and fishers. The forests of fir, pine, spruce, and larch provide little in the way of vegetable food, but the rivers teem with fish, and the forest with deer and small fur-bearing animals (*e.g.* beaver, skunk, marten, squirrel, etc.).

Like their neighbours to the north, the forest peoples wear warm, furry clothing, and live in skin tents which are usually pitched in a small clearing near a river, where the river fish and the forest animals are within easy reach. Because of the obvious difficulties of forest travel the chief means of transport is by canoe along the rivers. Contact with the white man has led to fur trading as an additional means of livelihood.

The Peoples of the Temperate Grass-lands

The Kirghiz of Central Asia are an example of people adapted to a grass-land environment. The only natural resource of the steppes is grass. There are few trees except for willows along the water-courses. Over large areas the rainfall is scanty and unreliable so that agriculture is undeveloped.

The Kirghiz are pastoral nomads who move from pasture to pasture with their flocks and herds of horses, camels, oxen, sheep, and goats. Although these people are so dependent on animals, meat forms only a small portion of their food. The herds are often depleted by blizzards and the attacks of wild animals (*e.g.* wolves); young animals must be kept to replenish the stock, while some are bartered for firearms, cotton cloth, tea, and flour. Cheese and milk, the latter often sour or fermented (*e.g.* koumiss), are the chief articles of diet. Vegetable food is scarce, and flat unleavened loaves, baked on hot stones, are a luxury. Owing to the scarcity of wood, the dried dung of animals is used as fuel for cooking.

Camel's hair cloth, leather, sheepskins, and cotton fabrics are used for clothing, sheepskin hats, coats, and long boots being characteristic articles of attire.

As in other nomadic communities the homes are portable tents (yurts). These are constructed of a circular willow trellis, covered with layers of felt made from the wool of the animals. The encampments are usually circular in form. During the summer many of the Kirghiz tribes migrate to the high, well-watered, rich grassy valleys of the neighbouring plateaux, where their dwellings are sometimes of a more permanent character, being built of stone.

The tents are richly furnished with rugs and carpets worked in beautiful patterns by the Kirghiz women. Most of their household goods are made of leather (*e.g.* bottles for carrying

milk) or sometimes of wood, for fragile articles would not stand the constant moving. The men fashion beautiful harness of leather.

The Kirghiz are fearless horsemen, and even young children are expert riders. As with other nomadic peoples, the women do most of the routine work, *i.e.* milking the animals and pitching camp. To the men fall the tasks demanding great spurts of energy and courage, *i.e.* the rounding up of straying herds, the repulse of wild animals, and the long hunting excursions in quest of game. They often return exhausted, and will rest, apparently indolent and lazy, for days.

Although living in Russian territory, the Kirghiz are a law unto themselves, the ruling of the oldest member of the tribe (the patriarch) being final in all disputes.

In recent years the Russian government, by extending its agricultural policy, has brought much of the former Kirghiz pastures under the plough, and is trying to convert the nomadic pastoralist into a settled agriculturalist.

In the North American prairies the Red Indian has virtually disappeared. He was never a herder like the Kirghiz, for the native animals, such as the bison, were not domesticated. Neither was the "gaucho" of the pampas a herdsman, because the South American grass-lands were originally the home, not of hoofed animals, but of large rodents such as the chinchilla, viscacha, and capybara. The same is true of Australia, where the only important animals of the grass-lands were marsupials such as the kangaroo. In South Africa, however, there are many black tribes who follow a mode of life similar to that of the Kirghiz. The Hottentots, for instance, depend largely on herds of oxen, live mainly on milk, and use the hides of their cattle for making cloaks, shields, etc.

The Peoples of the Hot Deserts

As noted in an earlier chapter the desert dwellers vary very much in type.

(1) Some live in permanent settlements in the oases and are both cultivators and herdsmen. They grow crops of rice, maize, fruits, onions, and tomatoes, and on the drier edges of the oases rear sheep, goats, and camels. Their diet is varied, and includes the all-important date, mutton, fruits, grain, and

vegetables. They live in flat-roofed houses made of sun-baked mud or stone. The oasis-dwellers are highly organised, and where trading brings them into periodic contact with the outside world, often reach a high cultural level. The peoples of the Saharan oases are of the type described above.

(2) Other desert-dwellers such as the Bedouins of Arabia and the Tuaregs of the Sahara are entirely nomadic. The driest portions of the desert have not even the scantiest vegetation suitable for grazing, but where the rainfall approaches 10 in. annually dry scrub and coarse grass is found. Here the nomads rear sheep, goats, and camels, wandering from pasture to pasture with their tents. The camel is invaluable, for it not only provides milk, but because of its speed and its ability to go without food or water for several days it is specially suitable for desert transport. The usual attire of the desert nomads consists of long flowing robes of white cotton cloth.

They are virile and courageous, but prone to acts of brigandage, plundering both oases and trading caravans to acquire food and other necessities in times of scarcity.

(3) In the Kalahari Desert live the Bushmen. These people are probably the descendants of the earliest inhabitants of Africa. Because of their isolation and the scanty resources of their environment, they rank among the most uncivilised and backward peoples in the world, comparable in many ways to the Australian "Black fellows".

Domestic animals and agriculture are unknown to them, but they are expert hunters, nimble, and fleet of foot. It is said that they can imitate the calls of every wild animal they know, and can approach within a few feet of the most timid animals to hurl their poison-tipped reed arrows. In fact, their inherent knowledge of nature and of the sources of natural poisons is probably unsurpassed by that of any other people.

Their food consists almost entirely of meat, often raw or decomposed, and in times of scarcity they will eat insects, snakes, and anything else they can obtain. They also dig for edible roots with primitive digging sticks. Because it is rarely cold they wear little clothing, usually a skin loin-cloth or a skin cloak (kaross). Their homes are extremely crude, and often consist of mats of plaited reeds hung in front of a rocky

recess or cave. Their most precious commodity is water, stores of which they hide beneath the sand.

Unlike the people who depend on domesticated animals, the Bushmen do not live in tribes but in small family groups, for otherwise there would be too many people in one place for the scanty supplies of game. They have great powers of endurance, and are patient, hardy, virile, and courageous. In times of scarcity, like other nomads, they often plunder the herds of neighbouring tribes.

The Peoples of the Savana

In the savana, as in the desert, the native peoples differ in their response to their environment. Three stages of cultural development may be distinguished: (1) pastoral peoples; (2) those who combine pastoralism with primitive agriculture; (3) agriculturalists.

(1) The Masai of the East African plateau are an example of pastoral peoples. They are a tall, strong, warlike race, partly negroid in type. They rear herds of cattle, sheep, and goats on the grass-lands, but since the savana grass-lands are richer than those of the steppes, their life is less nomadic than that of the Kirghiz. They eat little meat, their diet being almost entirely confined to milk and blood. In spite of the existence of a large variety of wild animals (antelope, gazelles, etc.) the Masai confine their hunting activities to the pursuit of the lion, the natural enemy of their herds. In lion hunting they show a degree of courage and daring which is almost unsurpassed. Because of the high temperature they wear little clothing. Their circular huts are composed of a framework of branches over which is smeared mud and animal dung. A group of such huts is enclosed by a circular thorn thicket within which the cattle are driven at night. In their wanderings the Masai come into conflict with the more settled peoples whose crops and stores they raid.

A Masai reserve has been established in Southern Kenya, but unfortunately much of this territory was too arid for cattle rearing, and so was disastrous for the Masai. The reserve has now been extended to include some of the richer grass-lands.

(2) The Kikuyu are a race of Bantu negroes who live to the north of Mount Kenya. These people combine agriculture with pastoralism. They not only rear cattle, but cultivate small plots of banana, manioc, and millet. Their homes and clothing are similar to those of the Masai, but their diet is more varied. They are also more settled and less warlike in disposition.

(3) The Hausas, a race of Sudanese negroes, live in the savana lands of West Africa, south of the Sahara. They are essentially a settled agricultural people, but their methods of farming are primitive. Until the period of colonisation by the white man, the Hausas did not use ploughs, but, as many still do, broke up the surface soil with hoes and digging sticks. On the crudely cultivated patches of land they grow cotton, millet, guinea corn, and ground-nuts. Formerly they did not rear cattle because of the raiding propensities of their neighbours, the Fulani. Under the more peaceful conditions of European government, and because they now realise the agricultural value of animal manure, they rear large numbers of long-horned cattle.

Their diet, as a result of the cultivated crops, is much more varied than that of other grass-land peoples. They live in villages and towns which are often walled, *e.g.* Kano, Sokoto. Groups of villages are united by allegiance to a common chief.

The Hausas have long been traders (*e.g.* the salt trade), and are skilled in the making of earthenware and leather goods, and the weaving of cotton cloth, and also make articles of iron. Influenced by contact with the Moslem peoples to the north, the Hausas wear flowing white garments, and in general have reached a higher cultural standard than most of the negro tribes.

The Peoples of the Equatorial Forest

The peoples of the equatorial forest also vary in their mode of life.

(1) The most primitive peoples are found where the forest is densest. They include the Pygmies of the Congo Basin, the Veddas of Ceylon, the head-hunting Indians of the Amazon Basin, the Kubus of Sumatra, and other similar tribes.

Because of the denseness of the vegetation and their inability to make clearings, these peoples are hunters who roam the forest in search of fruits and nuts, and who hunt wild animals (monkeys, etc.) with bows and poisoned arrows (or with blow-pipes in the Amazon Basin). They have no knowledge of domestic animals or agriculture, and rank among the most primitive groups of people in the world.

Because of the high temperatures they need little clothing, and are often completely naked. Their square huts have flimsy walls of sticks sometimes smeared with mud, and are thatched with leaves as a protection against the heat of the sun and the almost daily downpours of rain. Groups of such huts are usually to be found by streams, the source of water. As a rule these people are short in stature, and of poor physique. They are savage and mistrustful, and often so timid that they scatter into the forest at the least sign of intrusion.

(2) In the less dense forest the people are somewhat less backward, and combine primitive agriculture with their hunting activities. Some also rear chickens and goats. Examples of such peoples are the Gabun of French Equatorial Africa, the Bakuba of the Congo Basin, the Moi of Annam, and various tribes of the Philippines, Borneo, and the Amazon Basin.

The special system of agriculture characteristic of these peoples is known as Milpa or Fang agriculture. It consists of planting crops in temporary forest clearings. Every two or three years a new clearing is made and burned. In the rich mixture of soil and ashes are grown crops of rice, millet, bananas, manioc, or taro according to the locality. When the soil is exhausted another plot is cleared. Throughout the equatorial forests are to be found scattered patches of second growth timber, the mute record of Milpa agriculture. The native agriculturalist has to face many difficulties. His tools are primitive; the soil is by nature infertile; weeds grow with amazing rapidity; and much damage is done to the crops by wild animals such as elephants and monkeys.

These forest agriculturalists, moving periodically from plot to plot, are semi-nomadic, but are of a higher cultural level than those who do not practise agriculture at all. Their food supply is more certain and varied. Like them, however, they

wear few clothes, and build square, pointed, thatched huts which are usually placed along the edges of the forest clearing. Because of the danger from wild animals, and for other reasons, these houses are often raised on stakes, several feet above the ground level.

The primitive agriculturalists are generally of a peaceful and somewhat indolent type. Nature is so lavish in the equatorial regions that a minimum of work will provide an ample food supply. There is no season when food is short, and the storage of supplies for future use is unnecessary. Consequently, there is no incentive to steady work and progress, and such peoples are of little value for plantation work. Moreover, in these areas a considerable proportion of the population is infected with various tropical diseases, particularly malaria and diseases such as hookworm, caused by certain parasitic worms. The victims even when not acutely ill have their vitality sapped and become listless and lethargic.

These tropical diseases can be practically wiped out by modern medical science (as, for example, in the Panama Canal Zone), but the cost is great and the necessary measures demand co-operation from the native inhabitants that these are often too ignorant, or unwilling, to give.

CHAPTER XVIII

THE CEREALS

Distribution of Products

Rubber would not flourish in England, nor the olive in the Amazon Basin. For each important plant product there are certain conditions under which it thrives best. In this chapter the distribution of, and the conditions for the successful cultivation of, the chief products, both food and raw materials, will be outlined.

Wheat

Wheat is the most important of all the cereals, and has been cultivated for several thousand years. Wheat grains have been found in the Stone Age lake dwellings of Switzerland. Scientists believe they have discovered in Palestine the wild cereal from which the cultivated varieties of wheat have been evolved.

CONDITIONS OF GROWTH.—There are many varieties of wheat adapted to special conditions of soil and climate, but in general the following conditions are desirable for wheat cultivation:—

(1) A moderate rainfall, *i.e.* about 20 in. to 30 in., some of which must fall in the growing season.

(2) A period of warm, sunny weather for ripening.

(3) A moderately stiff loam, or a clayey soil.

(4) Land flat enough for the use of modern machinery on a large scale, but at the same time sufficiently undulating to be well drained.

The climate of Mediterranean regions satisfies these conditions, and so does that of the central areas of continents in the temperate zone. In the latter the rain comes mainly in the summer, and falls in the growing period of the early summer months. The late summer months, when the grain ripens, are dry. In Northern India the heavy rains of summer

are followed by winters sufficiently warm to ripen the grain. Hence wheat can be sown at the end of the monsoon rains and harvested in the winter months.

Areas of Production (Fig. 134).—The principal wheat-growing countries of the world may be divided into three groups:—

(1) The densely-populated countries of Western Europe, viz. Britain, France, Belgium, Holland, Denmark, Germany, etc. Because of the high price of land and the relatively dense population, farmers cultivate the land intensively, in

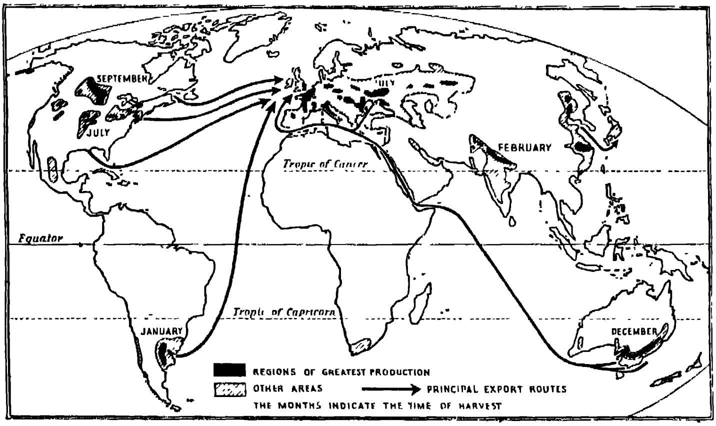


Fig. 134. Distribution of Wheat Production.

order to obtain a high yield (15-30 cwt per acre). Even with this yield the amount of wheat produced (except in France) is not sufficient to supply the needs of the people, and wheat has to be imported. Britain grows only 30 per cent. of her requirements.

(2) The more backward and less densely populated countries of Eastern and South-Eastern Europe. In these lands wheat is grown by small peasant farmers primarily to satisfy their own needs. The methods of production are not scientific, and the yield is much lower. In Russia before the War of 1914-18 the yield was only 4½ cwt per acre, but Russian wheat production has undergone great changes in

recent years. In spite of the low yield, countries with extensive fertile plains, such as Roumania and Hungary, may have a considerable surplus for export.

(3) The "new" lands, such as Canada, Argentina, Australia, and Central United States, where cultivation is of the extensive type on farms of very large area. Until recently, the yield averaged rather more than 9 cwt per acre, but the vast areas under cultivation made large quantities available for export to the densely-populated areas of Western Europe.

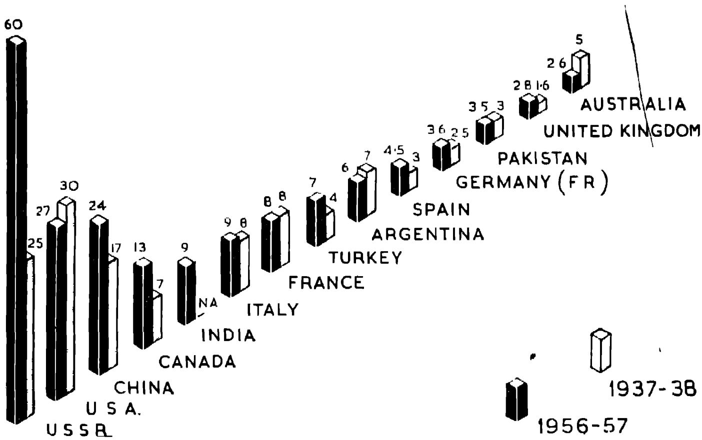


Fig. 135. World Production of Wheat in Millions of Tons.

Wheat yields have risen in most countries in recent years, owing to more scientific methods of farming and the increased use of fertilisers. In Canada the increase in yield per acre has been nearly 100 per cent. in the last fifteen years.

Recent Changes

Although the area sown to wheat is less than pre-war, production is up by about one-fifth, owing to improved types of wheat and more scientific methods of cultivation. Except for Russia and China, about one-fifth of the world's wheat is grown for export, and, in 1957, the four main exporting

countries held in store nearly enough for three years' exports. Evidently the area sown to wheat is too large. Production is in fact decreasing in North America and particularly in Canada, but it is rapidly increasing in the U.S.S.R at the present time. The U.S.S.R. is now by far the world's largest producer of wheat, and production in China is also increasing rapidly.

The principal importers of wheat are the United Kingdom, India, Germany, Italy, Belgium, Japan, and Brazil.

The United Kingdom crop, which during the war years rose to over 3,000,000 tons, is still half as large again as it was twenty years ago.

CHIEF WHEAT-EXPORTING COUNTRIES

(Exports in Millions of Tons)

	1934-8	1955-7
United States	1·3	9·5
Canada ..	4·8	6·6
Argentina .	3·3	1·5
France ..		1·1
Australia ..	2·8	1·0

Maize

Maize, or Indian corn, was originally grown in America, whence its cultivation has spread to most of the countries of the Old World. The grain is used as human food in Mexico, Italy, and many of the South American countries; in North America and Europe it is primarily used for feeding animals. The dried leaves and stems are used for paper making, and in parts of America, *e.g.* the lower St Lawrence Valley, the young green shoots are stored in silos for the winter feeding of cattle. (See plate facing page 257.)

REQUIREMENTS.– (*a*) A five months' growing season, the mean summer temperature being above 66° F.

(*b*) Summer rainfall to maintain plant growth.

(*c*) Deep, warm, and rich well-watered soils.

From the above conditions it is clear that maize will not ripen in lands with cool summers such as England; nor will it grow in lands with "Mediterranean" conditions of scanty

summer rainfall. Although it likes heat, it does not yield so well in very hot and wet countries.

CHIEF PRODUCING AREAS (Fig. 136).—(1) The "Corn Belt" of the United States, *i.e.* the central states of U.S.A. between the Canadian border and the latitude of St Louis. The bulk of the maize of this region is used for feeding animals (cattle and pigs) as at Chicago, St Louis, Omaha, Kansas, etc. Thus maize is the basis of the American meat packing, bacon curing, and allied industries.

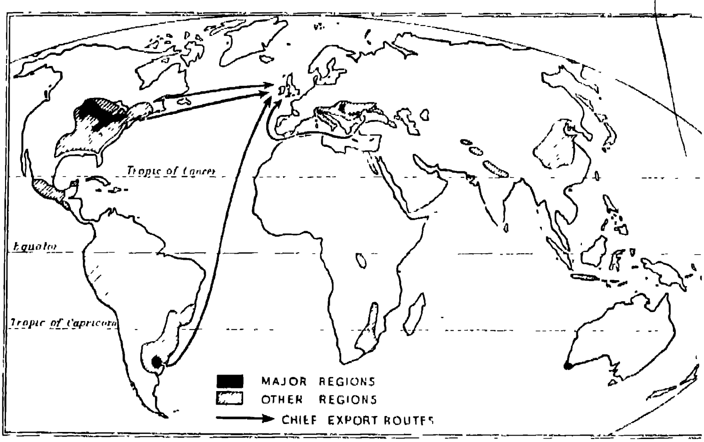


FIG. 136. DISTRIBUTION OF MAIZE PRODUCTION.

(2) Some maize is grown in the southern states of the United States, *i.e.* in the Cotton Belt. Much of this crop is used for food by the negroes.

(3) Maize is grown on the wetter pampas between the Parana and Uruguay Rivers in Argentina.

(4) All the states of Central America and the Andean states of South America grow maize for use as native food. There is no export from these states.

(5) The Danube lands and South Russia are the principal producers of maize in Europe, and Yugoslavia, the U.S.S.R., Roumania, and Hungary export to Western Europe.

(6) In some parts of the Mediterranean countries, *e.g.* the northern plains of Italy, where the summers are not too dry, or where irrigation can be practised, maize is grown and used for food by the peasant population.

(7) China, India, South Africa also grow maize for home consumption, and South Africa is now a leading exporter.

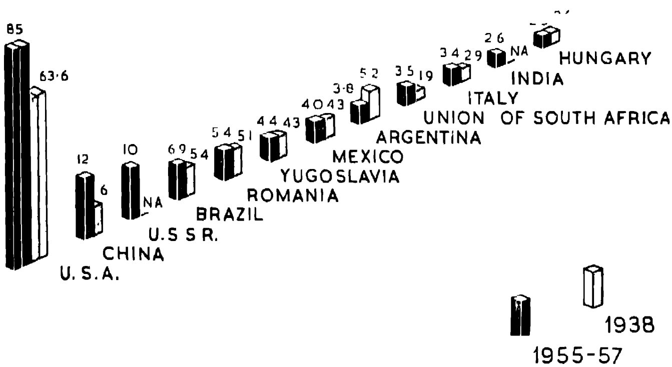


Fig. 137. World Production of Maize in Millions of Tons.

Recent Changes and World Trade (Fig. 137).—European production slumped during the war years but has now recovered and the U.S.S.R. has been exporting considerable amounts chiefly to the United Kingdom. Although Argentina produces so much less maize than the United States, the former country was the leading world exporter until 1939, since the United States hardly exported any of its maize crop and, indeed, often imported from the Argentine, where alfalfa is more generally used for cattle feeding. Production in the Argentine has fallen and the chief exporters in 1955-7 were: U.S.A., 3·4 million tons; Union of South Africa, 0·9; Argentina, 0·7. Total world production has increased by about one-fifth in the last twenty years. Russian production has greatly increased during the last few years, and in 1956 reached 12,000,000 tons.

Rice

Rice is the main food supply of about 50 per cent. of the world's population, and is primarily a product of South-East Asia.

REQUIREMENTS.—(*a*) A high summer temperature with an average of 70° F. throughout the growing period.

(*b*) Abundant moisture, well controlled so that the paddy fields can be flooded during the early period of growth.

(*c*) A permeable rich alluvial soil such as is found in deltaic areas, but the subsoil must be impermeable in order that the water will not drain away too readily.

(*d*) A plentiful supply of labour, because of the tedious and slow methods of rice culture, *e.g.* the transplantation of young seedlings in the flooded fields. The cultivation of rice requires patience, perseverance, and care.

Most of the rice grown is of the lowland or swamp type, which requires the above conditions, but another variety, known as upland rice, is grown in hilly districts with drier soil conditions.

REGIONS OF PRODUCTION (Fig. 138).—Rice-producing areas seem to fall into three groups:

(1) Those countries which have a very large production and at the same time a very dense population, so that there is no surplus for export. Such countries, in spite of being the chief rice producers, often import rice. In this group are China, Japan, India, and Indonesia.

(2) Those countries which have an appreciably lower production but a much smaller population, so that there are large supplies for export. In this group are Burma, Siam, and Formosa

(3) Non-Asiatic countries which produce *small* amounts of rice, often on irrigated lands, and use it mainly for home consumption.

(*a*) The United States in the Mississippi delta and the irrigated lands of California and Texas.

(*b*) The irrigated river valleys of the Peruvian desert.

(*c*) Egypt.

(*d*) The south-east of the Po Valley in Italy.

(*e*) The interior lowland of Yugoslavia.

(*f*) The irrigated lands of South-East Spain.

(*g*) Australia in the irrigated lands of the Murrumbidgee.

(*h*) Central America, West Indies, and British Guiana.

CHANGES IN PRODUCTION (FIG. 139).—Before the War of 1939-45 rice production was increasing in such countries as

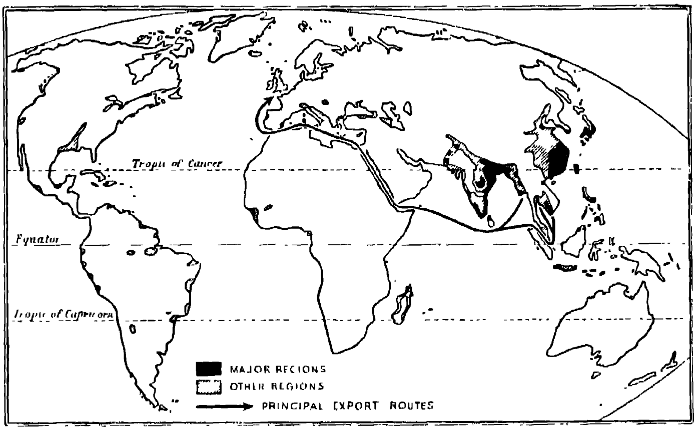


Fig. 138. DISTRIBUTION OF RICE PRODUCTION.

Korea, Siam, Indonesia, and Japan, largely to meet the local needs of a rapidly increasing population, particularly in Japan. Only about 9 per cent. of the pre-war crop entered world trade. Burma was the largest exporter with 3,000,000 tons, followed by Siam and Korea. More than half the Burmese export went to India.

The continued rapid increase in population and the dislocation due to war resulted in an alarming shortage of rice which was part of a general world grain shortage. World production of rice is now (1958) well above the pre-war figure and more than sufficient to meet the demand. In India, Ceylon,

and Japan there is a tendency to substitute wheat for rice as a food grain.

WORLD RICE TRADE (Millions of Tons)

Exporting Countries	1955-7	1936-40	Importing Countries	1955-7	1936-40
Burma ..	1·7	3·2	Japan ..	0·8	1·5
Siam	1·2	2·9	Malaya ..	0·6	0·8
U.S.A. ..	0·7	0·1	Ceylon ..	0 5	0·6
China ..	0·3	0 0	Indonesia	0·4	0 2
Italy ..	0 2	0 1	India ..	0·3	1·8

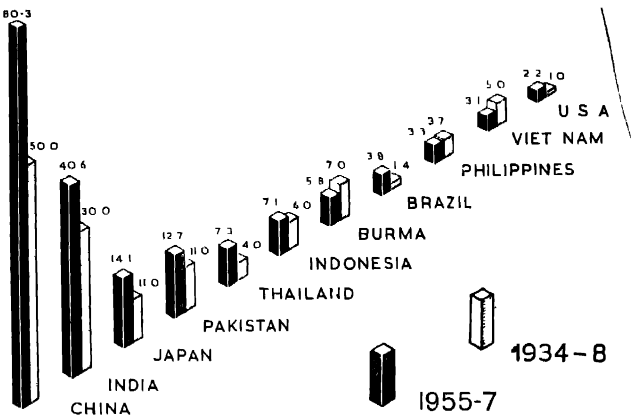


Fig. 139. World Production of Rice in Millions of Tons.

Other Cereals

Oats.—This cereal grows best in the cool, moist regions of the cool temperate zone, viz. in Great Britain, Ireland, parts of Germany, Central Russia, Central and Eastern Canada, and the cooler portions of the southern continents. The main use of oats is a food for animals, particularly horses. Oats flourish in the wheat lands, but will ripen in regions too moist and too cool for wheat.

In 1956-7 the principal producers and yields in millions of tons were: U.S.S.R., 20 to 30; U.S.A., 18; Canada, 7; France, 4; China, 3; Germany, 3; United Kingdom, 2; Poland, 2; Denmark, 1; Czechoslovakia, 1.

BARLEY.—This is another temperate zone cereal which grows well in the wheat areas, but it has a much greater range than wheat. It will grow, like oats, in cooler climates, and extends into more northerly latitudes than any other cereal. Unlike oats, it will grow in the warmer and drier lands of the temperate zone, and is therefore an important crop in Mediterranean lands, such as Morocco and the countries of South-West Asia. Barley is principally used for the making of malt for brewing, and for the distillation of whisky. Canada, U.S.A., and China are the largest producers.

RYE.—This is still another cereal of the temperate zone. Its outstanding characteristic is that it will thrive in very poor

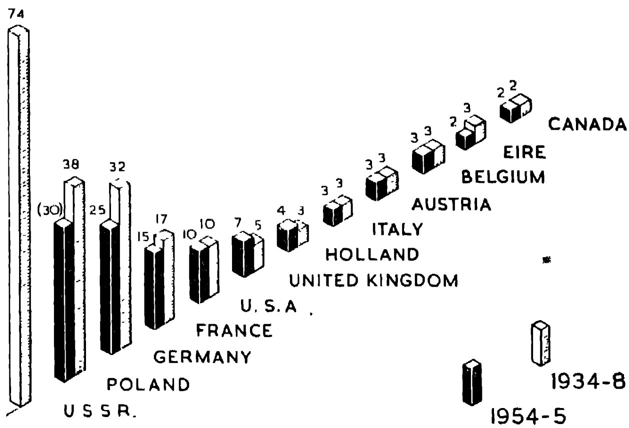


FIG. 139 (*a*). WORLD PRODUCTION OF POTATOES IN MILLIONS OF TONS.

soils, though it does not grow so far north as wheat and barley because it is injured by frost. The morainic soils of North Germany and Central Russia are used extensively for rye cultivation. The U.S.S.R., Poland, and Germany are by far the largest producers, with about twenty, seven, and five, million tons respectively.

MILLETS.—In the monsoon lands millets are cultivated where the rainfall is insufficient for rice (*i.e.* below 40 in.). There are many varieties of millets, known by different names, such as Dhurra, which is grown by most of the African tribes.

The principal growers of millets (including sorghum) are India 16 million tons, United States 3, French West Africa 2, Pakistan 1, Tanganyika 1.

POTATOES.—Although the potato is not a cereal it will be convenient to consider it here, as in many ways it can be used to supplement, or as a substitute for, cereals, as human food, as food for animals, and as a starting point for the manufacture of spirits and industrial alcohol. Since potatoes are bulky and do not keep well they do not feature in international trade on a large scale but are mainly grown for home consumption. The potato is well suited to a cool temperate climate, and the most important potato-growing areas stretch in a belt from Ireland eastwards across the Low Countries and Germany into Poland and the U.S.S.R. Of a total world production of about 230 million tons, nearly 210 million tons are grown in Europe. Potatoes are very liable to certain virus diseases, and hence the best "seed" potatoes are grown in cooler, more northerly areas (*e.g.* Scotland) which are too cold for the insects which elsewhere carry these infections from plant to plant.

PLATE 23

Above: Rice growing in Indonesia, an example of intensive cultivation where an enormous amount of cheap hand labour is available. The terracing enables rice to be flooded during the early stages of its growth and cultivation to be extended to the hills. (*Ewing Galloway, N.Y.*) *Below:* Agricultural land being destroyed by water erosion, with the formation of deep gullies. (*U.S.A. Soil Conservation Service.*)

PLATE 24

Above: British West Indies. Sugar-canes being cut a strip at a time and placed in bundles ready for the porters. (*Central Office of Information.*)

Below: Harvesting maize in the U.S.A. (*U.S. Information Service.*)

CHAPTER XIX

OTHER FOOD PRODUCTS

Tea

Tea is the dried leaf of a shrub native to South-East Asia.

REQUIREMENTS.—(1) Warm summers of tropical and sub-tropical lands, but a certain amount of frost is not injurious.

(2) Abundant rainfall.

(3) Good drainage, therefore it thrives best on hill slopes.

(4) Abundant supplies of cheap and skilled labour necessitated by the amount of work entailed in picking, drying, and packing the tea. Female labour is used because of the care needed in plucking the leaves from the shrub.

CULTIVATION AND PREPARATION.—For the establishment of a new tea-garden a plot of land is cleared and seedlings about one foot high are transplanted four feet apart. When they are three years old the bushes are ready for picking. They are pruned at regular intervals to facilitate picking and to stimulate the growth of new shoots. In China and the more backward areas of Japan, tea-gardens are about three to four acres in extent, and the tea is prepared by primitive hand methods. The tea plantations of India, Ceylon, Indonesia, and other parts of Japan, are much larger, varying from 300 to 1,000 acres, and up-to-date machinery is used. After the leaves have been gathered they are dried (sometimes in the open-air and sometimes by artificial heat), crushed and rolled, and dried again. At this stage the tea is a dull-green colour: for black tea the leaves go through a process of fermentation. Finally, the tea is graded and packed in lead-lined chests for export.

DISTRIBUTION (Fig. 140).—(1) Like rice, tea is essentially a product of the countries of South-East Asia, viz. (*a*) Southern Japan; (*b*) China, particularly the hilly regions of the South-East between Shanghai and Hong Kong; (*c*) India and Pakistan, especially in the north-east, in Assam, and the Nilgiri Hills of the south-west; (*d*) Ceylon; (*e*) Java.

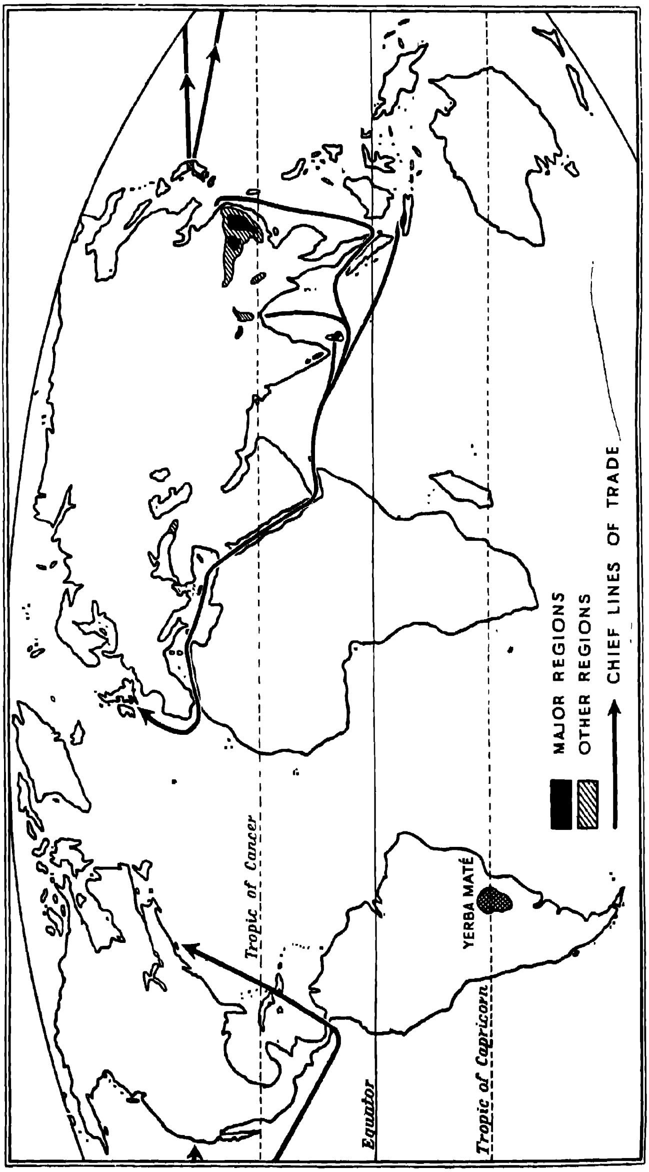


Fig. 140 Distribution of Tea Production.

(2) Although there are many other parts of the world with climatic conditions very similar to those of South-East Asia (see page 215), tea cultivation has made very little progress in other continents. Small amounts are produced in (*a*) East Africa (Kenya, Nyasaland, and Natal), (*b*) Fiji, (*c*) Jamaica, (*d*) Transcaucasia.

(3) There have been successful experiments in tea growing in South-Eastern Brazil, California, and South Carolina, but in these areas development has been restricted by the shortage of cheap labour.

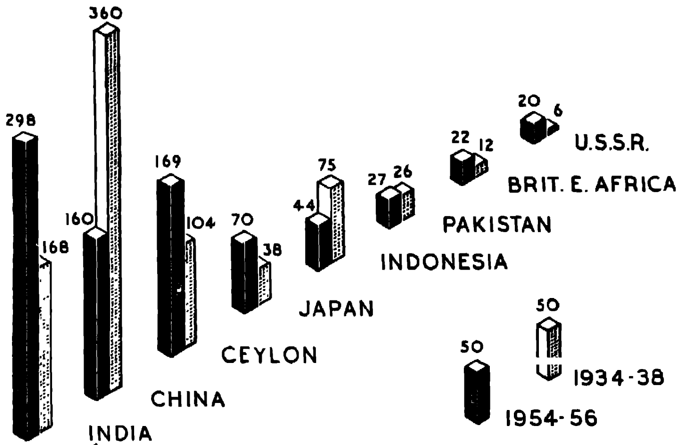


Fig. 141. WORLD PRODUCTION OF TEA IN THOUSANDS OF TONS.

TRADE AND CONSUMPTION (Fig. 141).—Up to 1840 China was the only country that exported tea. Tea growing was introduced into India by the British Government, and flourished to such an extent that India is now the leading exporter and Chinese exports have fallen greatly since 1880. Tea cultivation in Ceylon began later than in India, and was introduced when the coffee plantations were destroyed by blight at the end of last century. Ceylon now ranks second as a tea exporter. Tea production in Indonesia, which used to produce about one-fifth of the world's exportable crop, received a great setback during the Japanese

occupation when they were cut off from their world market—there were no exports during the years 1943-45. China also was unable to export during these years, but only a small proportion of Chinese production enters world trade. Total world production is now about one-fifth greater than before the war.

EXPORT OF TEA
(in Thousands of Tons)

	1938	1946	1947-9	1950-2	1954-6
India and Pakistan ..	175	158	202	205	207
Ceylon	107	146	147	140	159
Indonesia	80	2	12	33	33
China	46	7	8	20	(27)
British East Africa ..	10	12	12	12	16

Tea is used mainly by the Oriental and English-speaking peoples. The average consumption per head in 1956 was United Kingdom, 10·1 lb.; New Zealand, 6·6; Australia, 5·9; Canada, 2·8; Egypt, 1·3; Netherlands, 2; United States, 0·6.

Coffee

Coffee ranks next to tea in importance as a beverage. It was introduced to Arabia from the province of Kaffa in Abyssinia, and for two centuries Arabia was the main source of the world supply, but the demand was small. The coffee shrub bears red cherry-like fruits, each of which contains two coffee "berries". They are greyish-green in colour, and are not brown until they have been roasted.

REQUIREMENTS.—(1) An average temperature of 65°-75° all the year round.

(2) No frost, which is injurious to the plant.

(3) Heavy rainfall, 40-70 in.

(4) Well-drained land.

(5) Although coffee requires hot conditions it must be sheltered from the direct rays of the sun. Shelter is often provided by planting crops such as Indian corn or bananas between the rows of coffee trees. In Mocha (Arabia) the heat is modified by the prevalence of mists. It is clear that mountain or plateau slopes on the rainy eastern margins of continents within the tropics will be suitable for coffee growing. The

best coffee is usually grown at heights of from 3,000 to 6,000 ft.

There has been a tremendous increase in the use of coffee during the last fifty years, during which period the main centres of supply have changed. First, Arabia was the chief producer, then the West Indies, then Java, and finally Brazil, whose production out-distances that of all competitors.

PRODUCING AREAS.—(1) Brazil, on the plateau slopes in the state of San Paulo near Rio de Janeiro. Twenty years ago

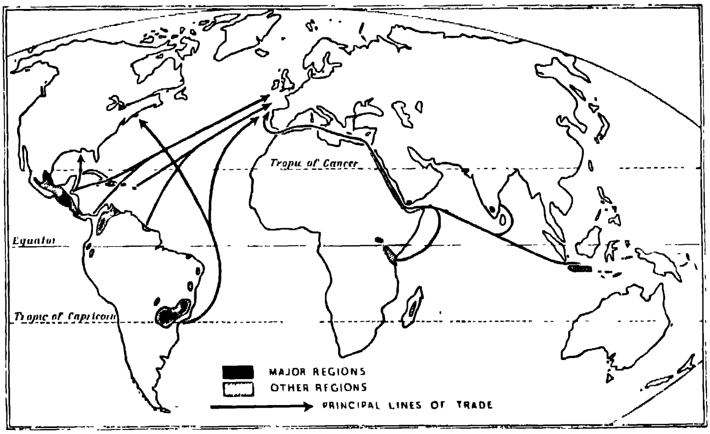


Fig. 142. DISTRIBUTION OF COFFEE PRODUCTION.

this relatively small area produced 70 per cent., and still produces almost 50 per cent., of the world's supply.

(2) The remainder of the coffee crop comes from small and widely-scattered areas, most of which produce a higher grade coffee than that of Brazil, where the methods of preparation for market are not so carefully carried out:—

(*a*) Central American States and islands, viz. Colombia, Guatemala, San Salvador, Jamaica, Mexico, Haiti, and Venezuela.

(*b*) Indonesia—Java (output greatly reduced by war).

(*c*) Africa—Ethiopia, Belgian Congo, French West Africa, Madagascar, Uganda, and Angola.

THE PROBLEM OF OVER-PRODUCTION.—Owing to the favourable conditions for coffee growing in Brazil, and the absence of other competitive crops, coffee production increased so rapidly as to outstrip the expansion of consumption in Europe and America. Since the Brazilian crop is not of the highest quality, the finer grades from other areas are sold first in the world market, and not all the Brazilian crop could be sold, so that a surplus accumulated.

In Brazil the size of the crop varies from year to year. Good weather conditions produce a bumper crop, and normally the year of high production is followed by two or three years of small yield, during which the growers are able

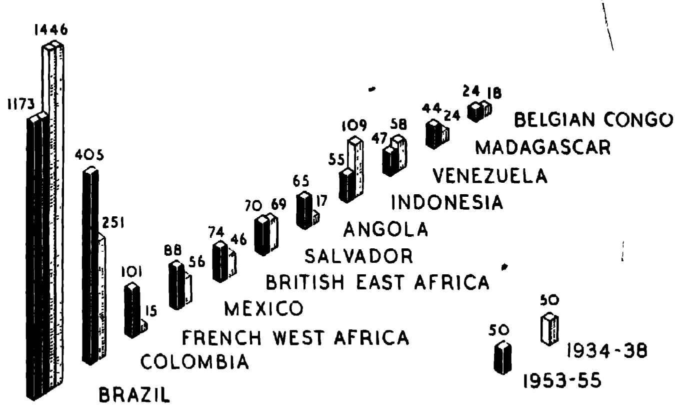


Fig. 143. WORLD PRODUCTION OF COFFEE IN THOUSANDS OF TONS

to sell at a high price the surplus accumulated during the "high yield" period. High prices encouraged a great extension of coffee planting, principally as a means of investing capital.

Unfortunately, from 1923 onwards there was a succession of "bumper" crops, and by 1930 large quantities remained unsold. By Government decree a large amount was destroyed, and control was exercised over the area to be planted under coffee each year. Even then the difficulties were not overcome, as a coffee shrub does not commence to bear fruit for about five years. Many coffee planters turned to other crops such as cotton, fruit, and oranges.

In nearly all the principal coffee-exporting countries, coffee is by far the chief export, accounting for four-fifths (in value) of the exports of Colombia, Guatemala, and Salvador, and for two-thirds of those of Brazil.

During the War of 1939-45 production fell about 20 per cent., mainly owing to a falling off in Brazil and Indonesia. For a while there was a severe shortage of coffee, but production is now a little larger than pre-war, owing to increasing amounts from the smaller producers. Over-production of coffee is once more a big problem, especially for Brazil.

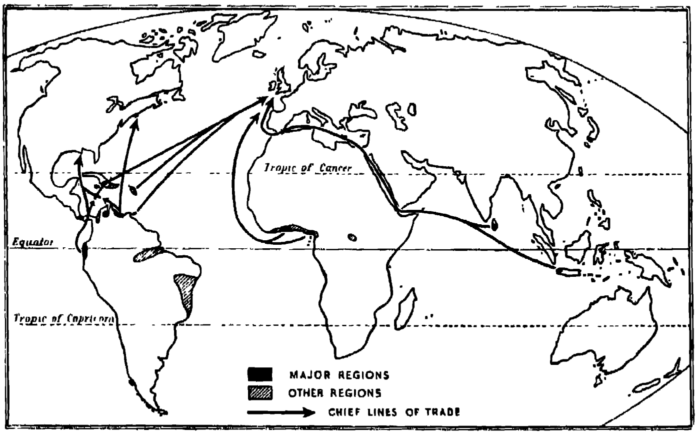


Fig. 144. Distribution of Cocoa Production.

Latin America produces about 80 per cent. of the world's coffee, only about a quarter of which comes to Europe. The United States is by far the largest consumer, taking two-thirds of the world's crop. The principal exporters in 1956-7 in thousands of tons were Brazil 876, Colombia 302, Uganda, Tanganyika, and Kenya 122, French West Africa 112, Mexico 85, Salvador 80, Angola 73, Guatemala 63.

Cocoa

Cocoa is the product of the fruit of the cacao tree. The flowers and fruits of this tree grow directly from the trunks and main branches. The cocoa beans are enclosed in large

fruits about 10 in. long. Fifty per cent. of the cocoa bean is a fat known as cocoa butter. used in making confectionery.

REQUIREMENTS.—(1) Great heat, *i.e.* a mean shade temperature of 80° with daily and seasonal variation less than 15°.

(2) At least 50 in. of rain well distributed.

(3) A well-drained, porous soil.

(4) Shelter from strong winds and the direct rays of the sun.

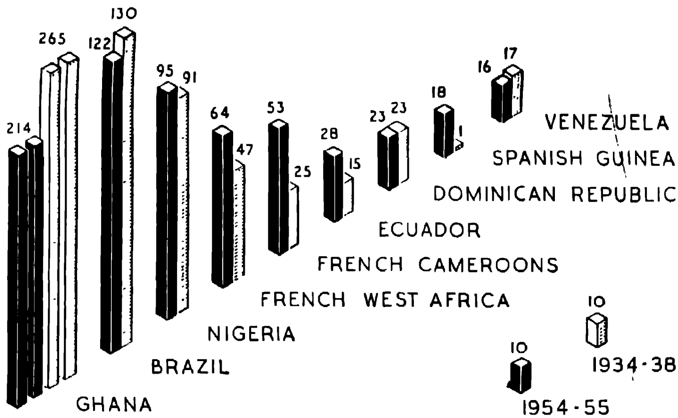


Fig. 145. WORLD PRODUCTION OF COCOA IN THOUSANDS OF TONS.

Because the cocoa tree requires shelter from winds, it grows best in regions of calms such as the equatorial low pressure areas, and on the lee side of mountains. Shelter from the sun is usually provided by planting bananas.

DISTRIBUTION.—(1) *West Africa*—Ghana, Cameroons, Nigeria, the islands of Fernando Po, Principe, and St Thomé.

(2) *America*—Brazil, Ecuador, Venezuela, Colombia, and in the sheltered valleys of many of the West Indian islands, viz. Trinidad, San Domingo, and Jamaica.

(3) *Asia.* Cocoa production is as yet not very important in the hot wet lands of Asia, but there are plantations in Ceylon and Java.

CHANGES IN CENTRES OF PRODUCTION.—At the beginning of this century the wet western lowland of Ecuador was the leading producer of cocoa, but the supply was only 10 per cent. of the world output. To-day Ghana is the leading producer, and with Nigeria produces almost 50 per cent. of the world's cocoa. The bulk of the cocoa used in Britain is grown by African peasant farmers in West Africa. The rise of West Africa as a cocoa-producing area was due to:—

(*a*) The greater political stability of the British colonies as compared with the South American States.

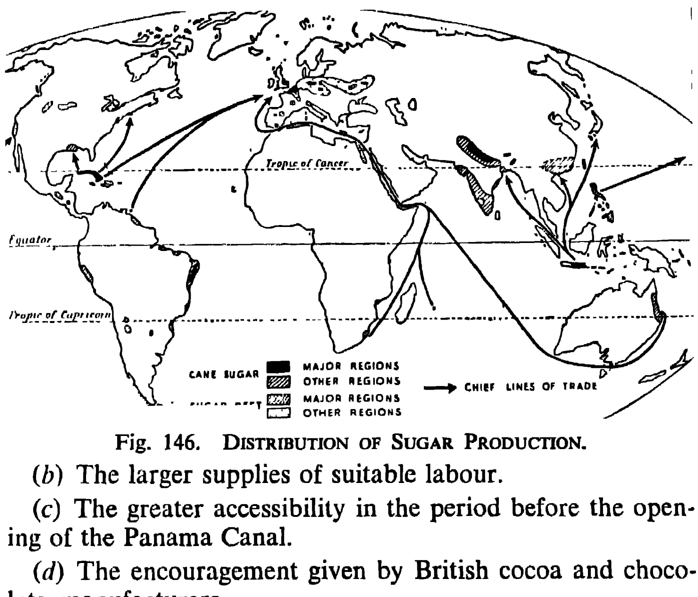


Fig. 146. DISTRIBUTION OF SUGAR PRODUCTION.

(*b*) The larger supplies of suitable labour.

(*c*) The greater accessibility in the period before the opening of the Panama Canal.

(*d*) The encouragement given by British cocoa and chocolate manufacturers.

The price of West African cocoa has risen very steeply in recent years and this, together with losses due to plant diseases, is already resulting in increased production in other areas.

Sugar-Cane

Sugar is present in many plants and in most fruits, and can be obtained from a variety of plants such as the maple, grape, date, maize, etc. But the bulk of the world's sugar is obtained from either the sugar-cane or the sugar-beet. As the former is

a product of the hot zones of the world, and the latter grows in the cool temperate zone, sugar is an example of a product in which there is competition between regions vastly different in development.

Cane-sugar (see plate facing page 257) is grown as a plantation crop mainly for export, while sugar-beet is grown mainly for home consumption, the sugar-beet sharing in a regular crop-rotation. A good deal of cane-sugar is refined at refineries in the industrialised temperate zone countries. About 95 per cent. of the sugar in international trade is cane-sugar.

REQUIREMENTS.—Sugar-cane requires:—

(*a*) Abundant heat with an average temperature of about 80° F.

(*b*) An abundant rainfall.

(*c*) A rich, deep soil. Where soil has been exhausted heavy manuring is essential.

(*d*) A lowland area.

These conditions are very similar to those for rice cultivation. In fact, good sugar-cane land is often good rice land, and vice versa.

Sugar-cane does not require the same amount of careful cultivation as sugar-beet, but the bulkiness of the cane makes transport a serious problem, especially in view of the damp and often muddy nature of the ground in which it grows. Sugar-cane is usually grown on estates of several thousand acres which have their own railway tracks and refineries, and are often not far from the sea.

DISTRIBUTION.—Since sugar-cane is a product of damp tropical lowlands, its cultivation, except in India and China, is mostly associated with islands and coastal plains (see Fig. 146). The most important sugar-cane producing islands are Cuba, Java, Hawaii, Puerto Rico, the Philippines, Mauritius, and Jamaica. In India and China sugar is cultivated on the wetter lowland areas; in Brazil on the hot, wet east coast plains, in the hinterlands of such towns as Pernambuco and Bahia; in the United States in the Mississippi delta; in the coastal lowlands of Natal; and on the hot, wet east coast plains of Queensland. In the last few years the output

of cane-sugar in Queensland has steadily increased, mainly as a result of the policy of Imperial Preference which allows colonial sugar to be imported into this country on lower tariffs than the sugar from countries outside the Empire. The Australian sugar is cultivated by white settlers, in spite of the great heat and humidity of the climate.

SUGAR TRADE.—(1) Cuba is by far the largest exporter of sugar (which forms four-fifths of the island's total exports). Sugar from Cuba, the Philippines, and Hawaii, goes mainly to the United States, because of the "preference" given by that country to these islands.

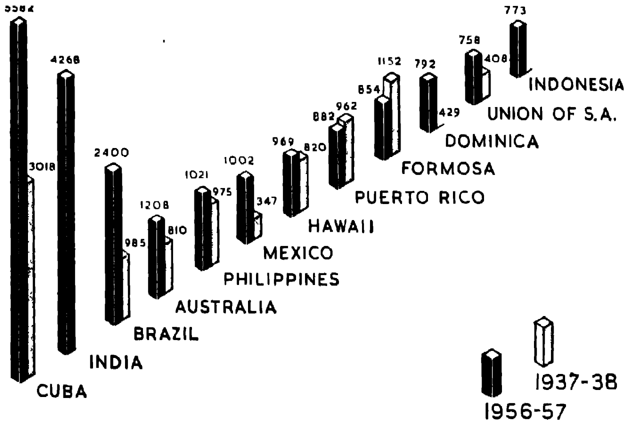


Fig. 147. WORLD PRODUCTION OF CANE-SUGAR IN THOUSANDS OF TONS
India and Pakistan produced 2,966,000 tons in 1937-8.

(2) The cane-sugar of Australia, Mauritius (over 95 per cent. of the island's total exports), Natal, and the British West Indies is exported to the United Kingdom.

(3) Formosan sugar goes to Japan. India, despite her large production, has no surplus for export.

(4) The largest importers are the United States and the United Kingdom, followed by Japan, Germany, Holland, and France.

Sugar-Beet

During the Napoleonic wars France was unable to obtain supplies of sugar from her colonies, and it was then that

sugar was first obtained from the sugar-beet. From that time onwards types of sugar-beet, giving a larger yield of sugar, have been developed. In contrast to sugar-cane, the sugar-beet grows in the cool temperate zone as a crop of the normal four years' rotation. It requires (*a*) a good deep stoneless soil; (*b*) rain from June to August; (*c*) a dry period in the autumn when the roots are lifted; (*d*) careful cultivation, especially weeding and thinning, so that much cheap labour is required. The extraction of sugar from the sugar-beet is a seasonal industry. From October to January the factories are working at great pressure. During the remainder of the year a few men only are employed, who thoroughly overhaul the machinery in preparation for the next season.

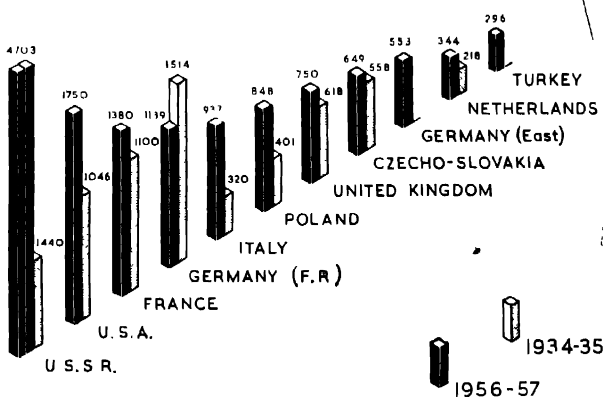


Fig. 148. World Production of Beet-Sugar in Thousands of Tons.

Distribution.—(1) The most important region for sugar-beet cultivation is the central plain of Europe, extending from Ireland through East Anglia, Northern France, Holland, and Belgium, Germany, Czechoslovakia, and Poland to Central Russia. Four regions are pre-eminent: (*a*) Northern France and Belgium; (*b*) Germany, around Magdeburg; (*c*) Czechoslovakia; (*d*) Russia, around Kiev and Kursk.

(2) Sugar-beet is grown to a less extent in North-Central U.S.A. and South-Central Canada (Fig. 146).

The beet-producing countries (except Britain) are largely self-supporting and some have a surplus for export. Thus

beet-sugar and cane-sugar compete in the world markets. A little over one-third of the world's sugar supply is derived from sugar-beet. The proportion of beet-sugar is decreasing slightly at present.

THE PROBLEM OF BEET-SUGAR AND CANE-SUGAR.—Competition between the growers of sugar-cane and sugar-beet first became acute in 1902. European countries, anxious to become independent of imported sugar, encouraged the home production of beet-sugar by subsidies and tariffs, and the West Indian industry suffered severely, and was compelled to introduce improved methods of sugar extraction in an endeavour to reduce the costs of production.

As a result of the 1939-45 War there was a world shortage of sugar. European sugar production dropped to about half during the war, and the Philippines, Java, and Formosa were unable to contribute to the world supply during the Japanese occupation. For several years production was nearly 20 per cent. below pre-war and in the meantime there had been a considerable increase in population (more than 11,000,000 in Central and Western Europe alone). Production is now 30 per cent. greater than before the war and more than equal to demand.

Mutton

The distribution of sheep is discussed on page 282. Sheep reared for mutton thrive best on good pasture land, though not as rich as that required for cattle-rearing. The chief wool-producing countries are also the chief mutton-producing countries, but, whereas Australia leads as a wool exporter, New Zealand exports more mutton. In New Zealand the sheep lands are the Canterbury Plains on the eastern side of South Island. In Australia, the Murray-Darling Basin is the principal sheep-rearing area, but this region is more liable to drought than the New Zealand plains. The Plate lowlands and Uruguay are the chief South American centres, but there is another region of importance in the extreme south of Argentina and Chile extending into Tierra del Fuego. Britain produces a large amount of mutton, but in spite of this she is the only major importer, taking nearly 95 per cent. of the world's total exports. In North America, sheep-rearing

is important in Ohio and on the western plateaux, but most of the mutton and wool are used in the home markets. In South Africa, sheep-rearing is concentrated in the uplands of the east of Cape Province, and some wool is exported.

Beef and Dairy Produce

Cattle are reared for beef, milk, hides, and as beasts of burden. Cattle need richer pastures than sheep, and where they are reared primarily for dairying the ideal climate is one of cool, damp summers and warm, damp winters. such as is experienced in Ireland or Cornwall. Under such conditions

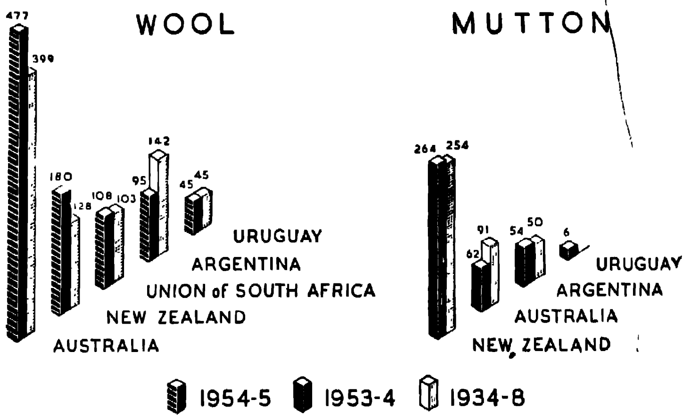


Fig. 149. CHIEF EXPORTERS OF WOOL AND MUTTON IN THOUSANDS OF TONS.

grass will grow throughout the year, and there is little necessity to resort to indoor feeding, which is practised in the lands of more extreme climate, such as Germany, Poland, etc.

Cattle will thrive in temperate and tropical lands. India has far greater numbers of cattle than any other country, but there they are used as "work" animals. The Hindus do not eat beef, and the Moslems eat very little. The Indian cattle yield little milk. Therefore India is important for neither beef nor dairy produce. Apart from India there are *three outstanding* regions for cattle production (Fig. 150):—

(1) The plains of Western Europe, including Ireland, England, Northern France, Belgium, Holland, Denmark,

Germany, Switzerland, and Northern Italy. In general, European herds are now rather larger than they were twenty years ago. In France, beef production has greatly increased and France is now a large exporter.

(2) The north-central plains of U.S.A. (*i.e.* the maize belt), but vast numbers of cattle are also reared in the high western plains.

(3) The temperate lowlands of South America, including the pampas lands, the Parana lowlands, Uruguay, and the extreme south-east of Brazil.

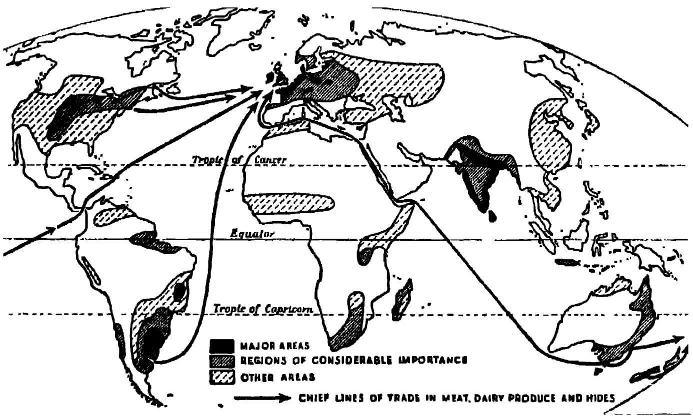


Fig. 150. DISTRIBUTION OF CATTLE.

In the early days of cattle-rearing, meat, which would not keep, could not be exported, and the chief exports were hides, fat, and bones. Hides and bones are still exported, the latter in large quantities to North Staffordshire for use in the manufacture of "bone china". At a later stage meat extracts were made and exported, but it was not until the processes of canning and refrigeration were perfected about 1870, means of transport improved, and carriage costs reduced, that meat could be exported in large quantities to Europe. At first the meat was frozen, but later it was "chilled", for it was discovered that meat could be preserved at temperatures slightly above freezing point, and that the fibres of the meat are not

torn by "chilling" as they are by freezing. From 1870 onwards the export of meat increased rapidly.

World beef production is now 50 per cent. above that of twenty years ago but the world's exportable surplus is 20 per cent. less. This is because of greatly increased consumption in the producer countries. Consumption of beef per head in the United States is twice, in Australia and New Zealand three times, and in the Argentine nearly five times, what it is in the United Kingdom.

Argentina is now the leading exporter of beef, followed by Australia, New Zealand, and France. The beef produced in the European zone is mainly used for home consumption, and the American supplies, though very large, are also used in America, leaving very little for export. Uruguay has also practically ceased to export. Great Britain is by far the world's largest importer of meat, only about half the beef and mutton we consume being home grown. In considering the exporting countries shown in Fig. 150 (*a*) it should be borne in mind that Eire also exports to the United Kingdom very large numbers of live cattle for slaughter in this country (over 600,000 in 1955). Denmark also exports live cattle, mainly to Western Germany.

DAIRY PRODUCE.—Cattle-rearing regions near to large centres of population usually have a highly-developed dairying industry to supply milk, butter, and cheese.

The greatest dairying regions are:—

(1) The cool, damp areas of North-West Europe, viz. in Denmark, Holland, and the British Isles and North-West France.

(2) Switzerland, where the Alpine pastures are the basis of important dairying activities.

(3) America, in the region south of the Great Lakes extending eastwards to New York and including the St Lawrence lowlands of Canada.

During the years following the War of 1914-18 there was a great increase in dairying in the temperate lands of the Southern Hemisphere, especially in the North Island of New Zealand, the east coast plain of Australia, and the eastern pampas of Argentina. The butter and cheese of these

countries finds a ready market in Europe, and, in spite of long-distance transport, often sells at a lower retail price than butter and cheese made in Europe.

As a result of the War of 1939-45 European production fell considerably despite the greater population. This was largely due to shortage of grain for feeding stuffs, and has since been made good.

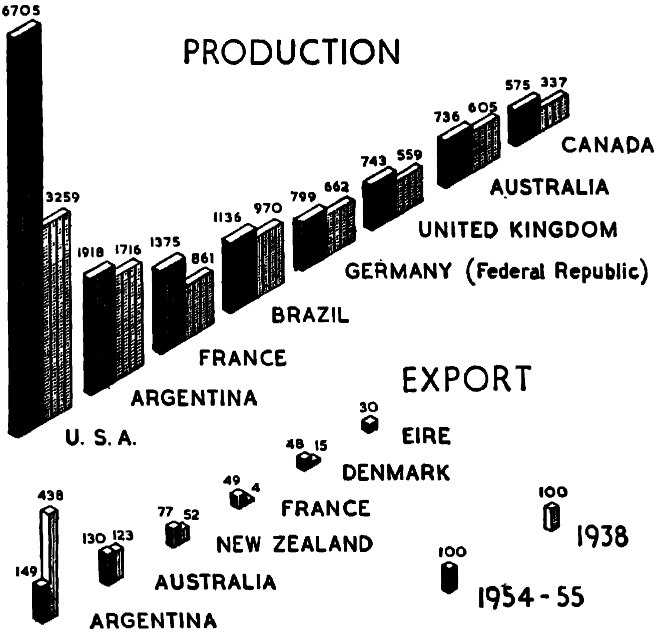


Fig. 150 (*a*). World Production and Export of Beef in Thousands of Tons. (Drawn to the same scale.)

Although more cheese is now being made than before the war, production of butter is down by one-fifth and the quantity available for export by one-third. The fall in exports is due to the absence of exports from Baltic and East European countries, reduced supplies from Australia, and the use of more fresh milk in Western Europe.

In the British Isles nearly four-fifths of the milk produced is consumed as liquid milk, only about one-fifth being "manufactured" into butter, cheese, dried or condensed milk, or milk chocolate. More than half the milk of most other countries is used for these manufactured products—in Denmark and Australia the percentage is over 80 and in New Zealand over 90.

Britain, spending nearly £150 million on imported dairy produce, is by far the world's biggest importer of dairy produce, taking nearly three-quarters of all butter exports, with Western Germany a very poor second.

New Zealand, Denmark, Australia, and the Netherlands are the chief exporters of butter. Eire, once an important exporter, no longer has a surplus available for export.

The principal exporters of cheese are the Netherlands, New Zealand, Denmark, Italy, and Australia. Eggs are exported mainly by the Netherlands and Denmark, and Western Germany is the chief importer, followed by the United Kingdom and Italy.

Although margarine, which is made from a wide variety of vegetable oils, is not a dairy product, it is a substitute for butter and hence may conveniently be considered here. The United States and the industrial countries of Western Europe are the chief manufacturers. The Netherlands and Norway are the chief exporters, but comparatively little enters international trade, and of this four-fifths is imported by the United Kingdom.

CHAPTER XX

THE MAJOR RAW MATERIALS

Rubber

Rubber is the coagulated juice or latex of various tropical plants and trees, the chief of which is the Hevea, a native of the Amazon forest. The Hevea tree yields a high quality rubber known as Para rubber, Para being the port at the mouth of the Amazon from which most of such rubber used to be exported. Rubber was introduced into Europe early in the eighteenth century, and for nearly a hundred years

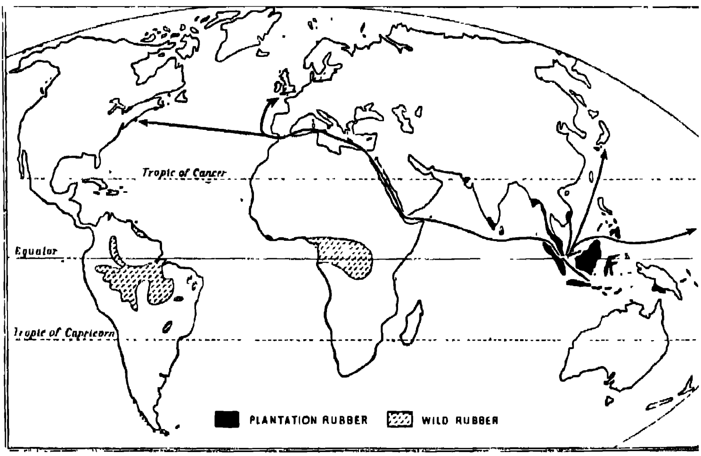


Fig. 151. Distribution of Rubber.

was only used for erasing pencil marks. In the early nineteenth century Mackintosh discovered that rubber could be used for making cloth waterproof, and in 1839 a further impetus was given to the use of rubber by the discovery of the vulcanising process, *i.e.* the addition of sulphur which makes rubber hard. It was not, however, until the end of the nineteenth and the beginning of the present century that the demand for rubber really attained great proportions. The rise of the bicycle, motor, and electrical industries have

resulted in a stupendous growth in rubber production. The old uneconomical method of tapping the irregularly-distributed wild rubber trees in the equatorial forest has given place to the organisation of compact plantations. The advantages of the plantation system are: —

(*a*) That a better quality rubber is obtained.

(*b*) There is a higher yield from each tree, and the collection is controlled.

(*c*) The collection of the rubber is much easier.

REQUIREMENTS.—The rubber trees require: —

(*a*) Great heat, a mean temperature of 80° F., never falling below 70° F.

(*b*) Heavy rainfall, 80 in. and upwards with no periods of drought.

(*c*) A lowland situation, but with good drainage and deep rich soil.

From the foregoing conditions it is clear that rubber trees will grow best in the equatorial lowland areas. An adequate supply of labour is a vital factor in the collection and preparation of rubber for market. The Amazon Basin is scantily peopled, and the natives do not easily adapt themselves to routine work. When the world demand for rubber increased, experiments were made to establish plantations elsewhere. In 1876 seeds from Brazil were germinated at Kew, and the young trees were dispatched to India and Ceylon, and thence to the Malay States and to Indonesia (Dutch East Indies). The remarkable increase in the world output of rubber and the change from South America to Asia as the main source of supply was due to the development of the plantation system of production.

RECENT CHANGES.—For many years attempts were made to manufacture a satisfactory synthetic rubber. The unexpected loss of the bulk of the world's supply of natural rubber during the War of 1939-45, owing to the Japanese occupation of Malaya and Indonesia, led to enormous developments in North America. Nearly half of the world's total rubber

production is now synthetic, and this proportion seems likely to increase. A large but unknown amount (probably well over 200,000 tons) is manufactured in the U.S.S.R. Production began in the United Kingdom in 1956, and by 1959 is expected to be over 50,000 tons a year. But while synthetic rubber is excellent for certain restricted purposes it is not yet as satisfactory as natural rubber for general purposes, such as tyres, although it is now cheaper in the United States than the natural product.

The recovery of rubber production after the Japanese occupation was greatly retarded in Indonesia, Burma, and

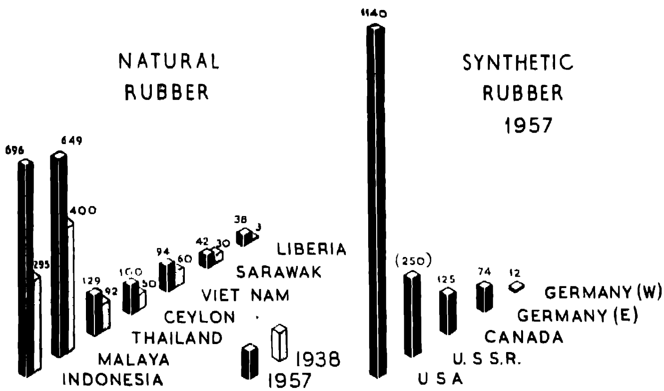


Fig. 152. World Production of Natural and Synthetic Rubber in Thousands of Tons.

Indo-China by political unrest, and Malaya gained a big start. Subsequently, Communist troubles in Malaya handicapped production, and by 1951 Indonesia had taken the lead. World production has now overtaken demand, a serious matter for the sterling area as Malayan rubber is its biggest "dollar-earner", the United States, on account of its huge motor industry, being by far the world's greatest consumer of rubber and taking more than half the world's output of the natural product to supplement its own vast production of synthetic rubber. Much of Ceylon's rubber goes to China.

Cotton

Cotton is the most important of all fibres used in the manufacture of textiles. Before 1800 it was one of the most expensive fibres because of the cost and difficulty of its preparation for the market. The cotton seeds had to be removed from the fibres by hand. In 1793 the cotton gin, a machine which separated the seeds from the fibres, was invented. This labour-saving machine cheapened the production of cotton, and its cultivation extended rapidly, particularly in the southern United States. There are many varieties of cotton, and the value of each type depends largely upon the length of the fibre or "staple". (See plate facing page 288.)

WORLD PRODUCTION OF CHIEF INDUSTRIAL FIBRES
(Thousands of Tons)

	1956-7	1938
Cotton	9,283	6,880
Rayon	2,262	960
Jute	1,809	1,256
Flax	1,421	787
Wool	1,312	830
Hemp	1,156	566
Nylon, etc.	308	1
Silk	29	60

Sea Island cotton, grown on the coastal lands of Georgia and in the West Indies, has fibres over two inches long, and surpasses all other varieties. Meade cotton is a close rival of Sea Island cotton, and is tending to replace it in U.S.A., because of the susceptibility of the latter to attack by the boll weevil, an insect which causes the cotton bolls to shrivel up. Egyptian cotton is also of excellent quality, and is grown by irrigation in a very dry and hot climate. Attempts to grow Egyptian cotton elsewhere have not been successful, except by irrigation in hot desert and semi-desert regions, as in the lower Colorado Valley and the coastal desert of Peru.

The bulk of the world's cotton crop is known as American Upland with fibres less than one inch long. In many cotton-producing countries cotton is short-stapled and only suitable for the spinning of coarse threads and the weaving of coarse materials.

Conditions for Growth.—Cotton requires:—

(*a*) Ample rain in the early growing season.
(*b*) A dry picking season in the autumn.
(*c*) At least seven months without frost.
(*d*) A summer temperature of 75° F.
(*e*) Abundant labour in the picking season.

Cotton grows between 40° N. and 30° S., its most northerly extension being in the Southern Ukraine (Fig. 153). Although the cotton plant needs heat and moisture, it does not yield well

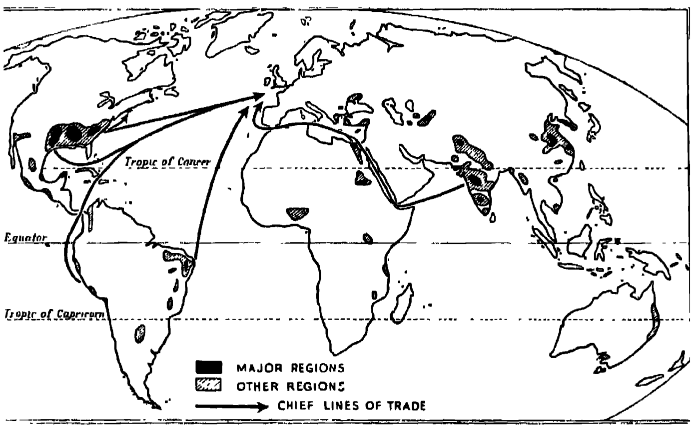


Fig. 153. World Distribution of Cotton.

in regions of constant heat, but will flourish best near to the cooler and drier margins of the cotton-growing regions. The approach of winter cold or of drought stimulates the plants to higher yields. Cotton is grown on small farms by peasant farmers, and not on extensive plantations. This is partly due to the social and agricultural background of the cotton-growing countries, China, India, Egypt, etc., and largely to the vast amount of labour required for picking. Machines have been invented to pick ripe cotton bolls and their use is increasing, but they are not yet very satisfactory.

Changes in Cotton Production.—(1) The American cotton region is the most important in the world. Cotton is

cultivated in some eighteen states of the south-east of the United States, being limited in the west by aridity and on the north by frost. The Gulf Coast Plains and Florida are too wet for cotton growing. There are three American areas of outstanding importance: —

(*a*) The Black Prairie of Texas.

(*b*) The Mississippi bottoms, viz. the flood plain of alluvial soil between Memphis and Vicksburg.

(*c*) The rich clay belts of Georgia and South Carolina.

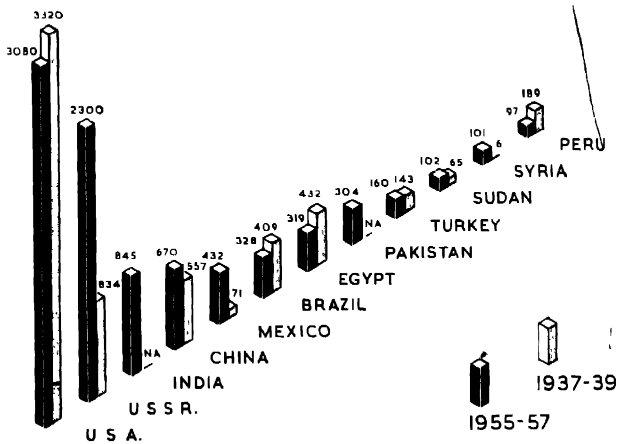


Fig. 154. WORLD PRODUCTION OF COTTON IN THOUSANDS OF TONS.

The United States provides about one-third of the world's cotton exports. Manufacturing regions of other countries largely depend on the American surplus for their raw material, but production has been increasing in many of the smaller areas. As a result, the United States has been over-producing for several years, and attempts to reduce output by restricting the area planted have been unsuccessful as the yield per acre has more than doubled since 1938 because of better methods of cultivation.

(2) Russia is producing far more cotton than thirty years ago, as a result of the development of Uzbekistan (which produces nearly two-thirds of the Russian crop) under the

Five-Year Plans, the opening up of new cotton lands in the Southern Ukraine, and Russia's determination to supply her own raw material. Russia now claims second place in world production and exports a considerable quantity.

(3) In Japan, cotton cultivation has virtually disappeared, the land being used for rice growing. India and Pakistan together are third to the U.S.A. and U.S.S.R. in production. The rather low-grade product is one of Pakistan's chief exports.

(4) Production in Brazil increased fourfold between 1932 and 1939, largely in place of coffee.

(5) The cotton mills of Lancashire were badly affected by the cotton shortage resultant on the American Civil War. The British Cotton Growers' Association was formed to encourage cotton production in suitable areas within the Empire in order that Lancashire should escape from its dependence on the United States. This brought about a general increase in the African crops, particularly in the Sudan, where millions of pounds have been spent on irrigation works (*e.g.* Sennar Dam on the Blue Nile).

(6) Other cotton-producing areas are Uganda, Northern Nigeria, Nyasaland, and Rhodesia in Africa; Southern Turkey and Syria and Iraq in South-Western Asia; Mexico, the West Indies, Venezuela, Eastern Brazil, Northern Argentina, and Western Peru in South America; and Eastern Queensland in Australia.

Although the cotton crop is distributed throughout so many countries, a shortage due to a bad season in one region cannot necessarily be balanced by a bumper crop in another, for the machinery used for spinning and weaving long-stapled varieties is not the same as that used for short-stapled varieties. Hence a particular manufacturing area may be badly affected by crop failure in a single area of production.

Nearly all the U.S.S.R., Indian, and Chinese cotton and three-quarters of the U.S.A. crop is retained for manufacture. The United Kingdom is the principal customer for Egyptian cotton (in value about nine-tenths of Egypt's total exports) and Japan for Pakistan's cotton. Japan is the largest, and the United Kingdom the second largest, purchaser of U.S.A. cotton.

EXPORTERS OF RAW COTTON, 1955-6
(Thousands of Tons)

U.S.A. ..	792	Brazil ..	158
Mexico ..	385	Pakistan ..	149
U.S.S.R.(1957)	319	Peru	142
Egypt ..	254	Sudan	103

COTTON MANUFACTURING.—The principal cotton manufacturing regions of the world are South-East Lancashire, the New England States, North and South Carolina, India (Bombay), China (Shanghai), Japan (Osaka), Northern Italy, Switzerland, North-East France, Belgium, and Westphalia.

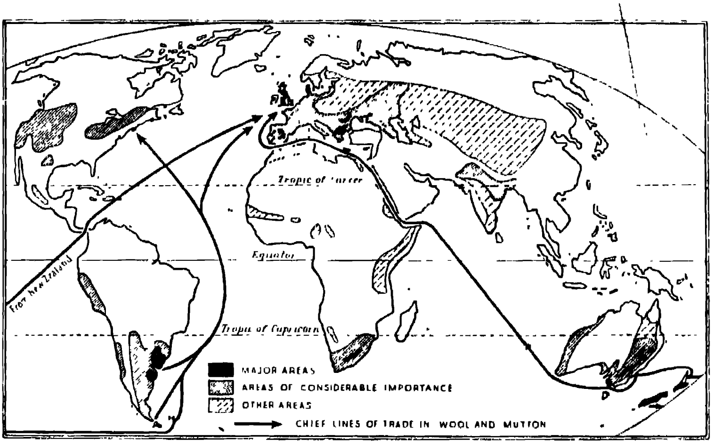


Fig. 155. DISTRIBUTION OF SHEEP.

Wool

Sheep-rearing areas can be divided into two main groups:—

(1) The unproductive lands of the "old" countries of the Northern Hemisphere, viz. Central Spain, the highlands of the British Isles, and the highlands of South-East Europe.

(2) Those "new" countries of the Southern Hemisphere where land is plentiful and cheap, and the population density is relatively low, viz. Australia, South Africa, Argentina, New Zealand, and Uruguay.

The sheep-rearing areas of the mountain zones of U.S.A. fall into the second category. American wool is used in American woollen mills, and there is no surplus for export.

The countries of the Southern Hemisphere are the leading producers and exporters. Australia produces about 30 per cent. of the world's supply, so that no country dominates the wool trade (cf. Brazilian coffee, American cotton, Asiatic rubber).

Sheep are reared for both wool and meat, but sheep which yield excellent wool usually provide poor meat, and vice versa. There are two main classes of wool, Merino wool, of a fine silky texture, and cross-bred wool, of less fine quality.

But the rearing of cross-bred sheep is of great advantage to the sheep farmer, for if wool prices fall he can increase his

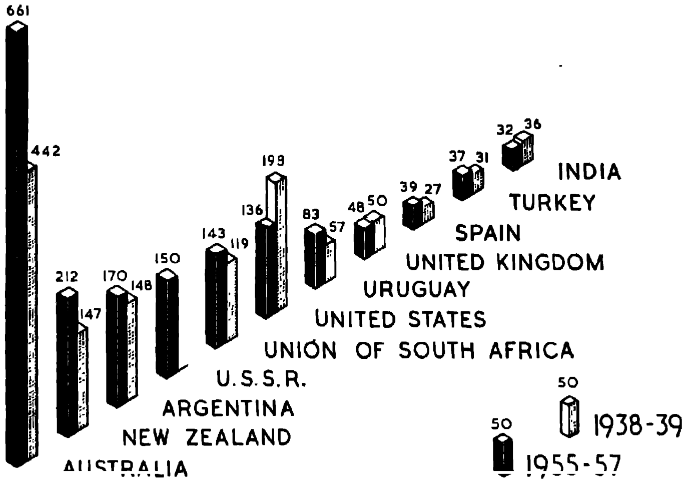


Fig. 156. World Production of Wool in Thousands of Tons (Greasy).

income by the sale of mutton. It is because sheep farmers can increase their supply of wool relative to mutton, and vice versa, that the wool markets of the world have not been subjected to the restrictions applied to other commodities such as rubber, sugar, etc., and that financial crises have not developed to the same extent in the wool trade.

Other types of wool, or animal fibres, are also used in the textile industries. The most important are:—

(1) The wool of the alpaca and vicuna, animals which live in the Andean regions of South America.

(2) Camel's hair.

(3) The wool of the Cashmere goat.

(4) Mohair, the wool of the Angora goat, a native of Asiatic Turkey. The chief centre of production is South Africa.

Flax

Flax is a fibre obtained from the stems of the flax plant. After the plant has been pulled it is "retted", *i.e.* soaked in water to produce partial decay which facilitates the removal of the fibre. The flax plant yields seed (linseed) as well as fibre. If the plant is being grown for fibre it requires cool

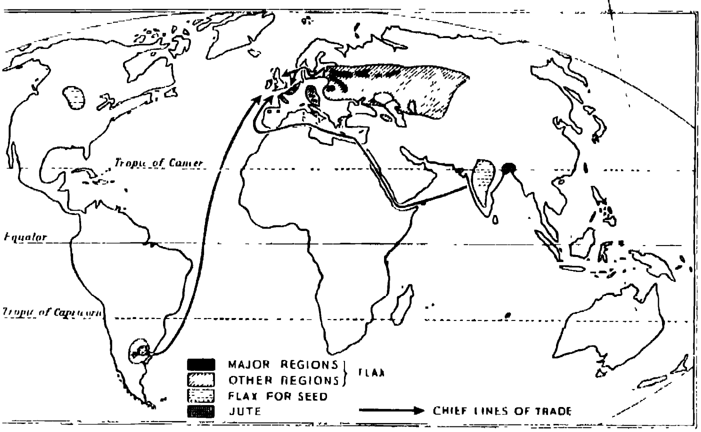


Fig. 157. Distribution of Flax, Linseed, and Jute.

damp conditions of the cool temperate zone (*i.e.* 49° N. to 55° N.). A hot dry summer results in coarse fibre. The seeds are set very closely, so that the plant will grow as tall as possible and thus increase the fibre yield. Flax exhausts the soil, so that it is rarely grown on the same piece of ground more than once in eight years. Retting is still mainly done by hand, so the large-scale cultivation of flax is chiefly in areas with low labour costs.

For linseed, flax is grown in warmer latitudes (see "Oil Seeds").

Distribution of Flax Growing.—The distribution of flax is in many ways similar to that of sugar-beet, for the

outstanding regions are in the Central Plain of Europe extending from Ireland to Russia. The latter country is the leading producer, with over 80 per cent. of the total world crop, which is about 1,400,000 tons. Russian exports of flax are increasing, but are still only a very small proportion of the total production. Belgian flax is of very high quality, and although there are important linen manufactures in Belgium, much of the flax is sent to Northern Ireland, where the growing of flax has almost ceased. During the war years the output of Belgium, France, and the Netherlands increased owing to

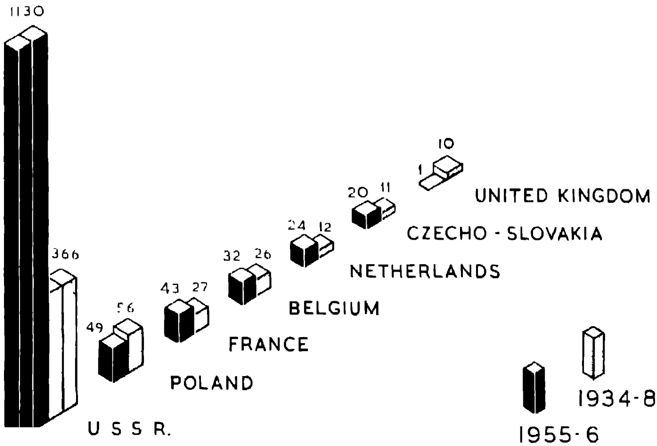


Fig. 158. WORLD PRODUCTION OF FLAX (FIBRE) IN THOUSANDS OF TONS.

the small amounts of Eastern European flax coming on the market.

LINEN MANUFACTURE.—The manufacture of linen is especially important in Great Britain, *e.g.* in Northern Ireland and Eastern Scotland. Irish linen is exported to all parts of the world. Other manufacturing centres are Northern France, Belgium, the Ruhr Valley, and Northern Italy. Japan has increased her linen manufactures in recent years.

Hemp

True hemp is, like flax, a fibre obtained from the stem of a plant. Its preparation resembles that of flax, and its

geographical distribution is very similar, for the largest supplies of European hemp come from the flax regions of Russia. Hemp is used for the manufacture of ropes, string, the backing of carpets and linoleum, canvas, etc. Italy is the second largest European producer, and Italian hemp from the district around Bologna is of excellent quality.

There are many other fibres to which the name "hemp" is applied.

(1) Manila Hemp.—This is cultivated in the Philippines. Attempts to introduce it into other countries have failed. It is the fibre of the stalk of a plant allied to the banana plant and in fact is so similar to the banana that only experts can detect the difference. It makes very strong rope, especially for ships' rigging, and is used in the manufacture of strong paper, and to make the binding cord used in harvesting machines.

(2) Sisal Hemp.—This is the fibre of the stiff sword-like leaves of the henequen plant. Practically the whole of the world's supply comes from the lowland peninsula of Yucatan in Mexico. It has been introduced with some success to some of the West Indian islands and to Kenya and Tanganyika Territory. It is not as strong as Manila hemp, but is cheaper.

(3) Phormium.—Phormium, or New Zealand flax, is a kind of hemp grown throughout New Zealand.

Jute

Jute is the cheapest of all fibres. It cannot be bleached, and is used for the manufacture of cords and sacking. It has been called "the brown paper of wholesale trade", for it is used for packing many commodities of world trade, *e.g.* bales of cotton and wool; as sacks for coffee, wheat, etc.

About 99 per cent. of the world's jute (over one million tons) is produced in the lower Ganges Valley, 55 per cent. in Pakistan, and the greatest number of jute mills are in the neighbourhood of Calcutta in the Dominion of India. It is manufactured in Dundee and Philadelphia (for carpet backing). Some small quantities are cultivated in Formosa and Brazil. Pakistan is almost the sole exporter, and India the largest importer, followed by the United Kingdom, Belgium, and Germany, in that order. Jute accounts for 40 per cent. of Pakistan's total exports.

Silk

Silk is obtained from the cocoons of the silkworm. As the chief food of the silkworm is the leaves of the white mulberry, the distribution of the silkworm corresponds closely to the distribution of the mulberry tree. As a second crop of leaves is required for feeding, the temperature must be at least 55° F. for three months, but the silkworm cannot stand temperatures less than 60° F., so in many of the cooler areas they are kept in slightly warmed rooms. The unwinding of the silk fibres from the cocoon demands an abundant supply of highly-skilled cheap labour, and this, even more than climatic conditions, limits silk production.

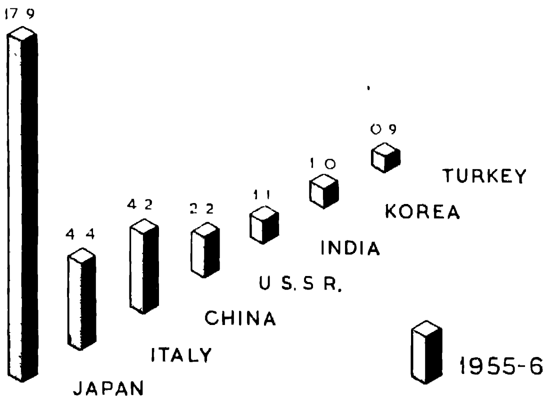


Fig. 159. World Production of Silk in Thousands of Tons.

The silk production of the world is centred in two large areas: —

(1) The south-east of Asia, supplying about 80 per cent. of the world output.

(2) The Mediterranean countries of Europe, which supply nearly all the remainder.

In China, silk production is chiefly centred in the Yangtse-Kiang and Si-Kiang Valleys. Only a very small proportion is exported.

Japan's output increased enormously early in the twentieth century. Silk culture is to Japan what sheep-rearing is to

England, for the mulberry can be grown on mountain slopes too steep for cultivation, and so it is a valuable means of using land that would otherwise be unproductive. Until 1933 silk was the most important Japanese export (20 per cent. by value), but it was down to 13 per cent. by 1938, and is now far exceeded by cotton goods. The United States is by far the biggest importer of silk, taking 80 per cent. of the Japanese exports and 50 per cent. of the Italian. World production of silk is less than one-third of what it was twenty-five years ago.

The fertile plains of the Po Valley yield about 90 per cent. of the European supply. Mulberry trees are used as supports

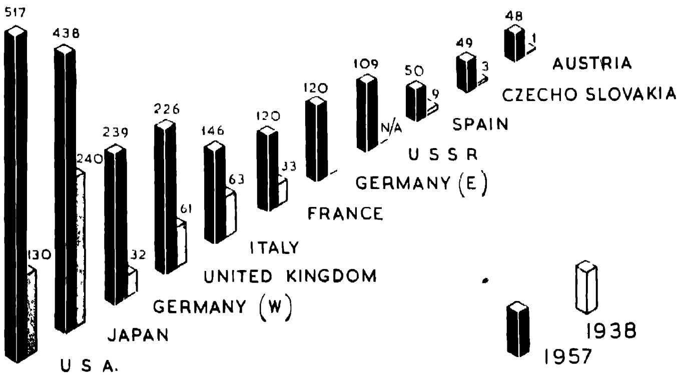


Fig. 160. World Production of Rayon in Thousands of Tons.

for grape vines, and wheat is harvested on the intervening land, an example of intensive agriculture in a land of dense population. The silk is woven in the factories of Milan. Silk is also produced in the Rhône Valley south of Lyons; in Eastern Spain; and in the western plains of Asiatic Turkey.

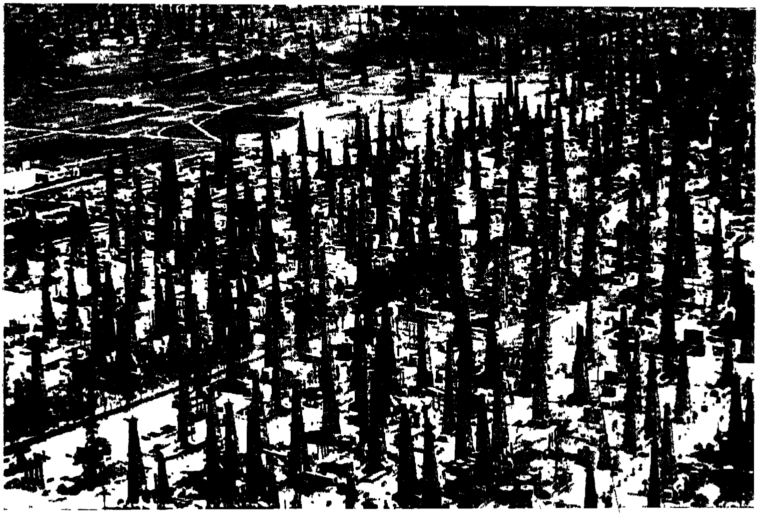
Rayon

Rayon is made by the treatment of wood pulp, cotton, and other vegetable materials with various chemicals to form cellulose. This is forced through minute holes in glass to make silk threads. Rayon ("artificial silk") has not replaced real silk, for, apart from its appearance, rayon has few of the

PLATE 25

Above: African producer picking cotton in Nyasaland. (*Central Office of Information.*)

Below: Ceylon: Tapping rubber trees. (*Exclusive News Agency.*)



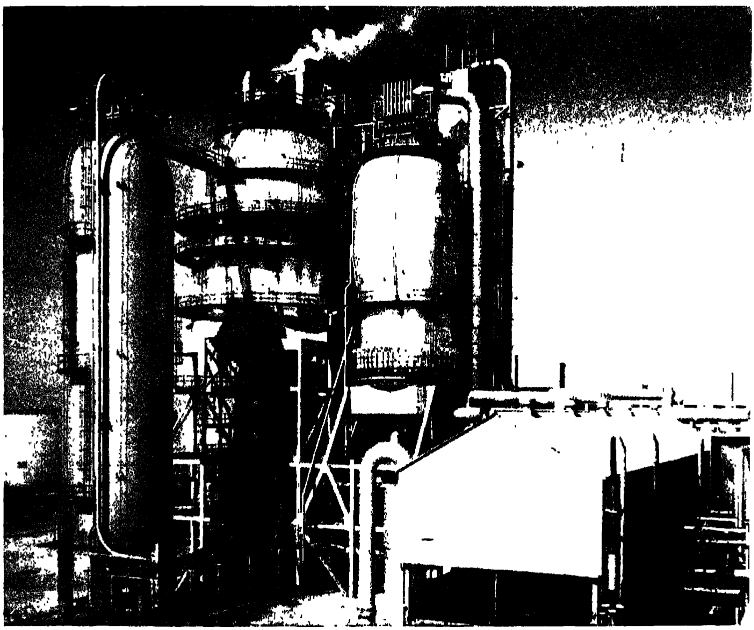


PLATE 26

Above: An oilfield in California. (*U.S. Information Service.*) *Below:* The catalytic cracking plant at the refinery at Fawley, near Southampton. (*Esso Petroleum Co. Ltd.*)

qualities of pure silk. However, owing to the abundance and cheapness of the necessary raw materials, its output is now enormously greater than that of real silk. Its production exceeded that of wool before the War of 1939-45, and it is now nearly twice as great. Its tendency is to replace fabrics made of cotton, wool, etc., but it is also extensively used for mixing with other textile fibres. Japan was the largest producer before the war, but in the immediate post-war years her output was very small. She has now recovered and takes second place to the United States, with the United Kingdom fourth. During the trade depression of the 1930's many of the cotton mills in Lancashire were converted for the production of rayon.

Nylon

World production of purely synthetic fibres, of which nylon is the most important, is now nearly 300,000 tons. The United States is by far the largest producer, with Japan in second place, and the United Kingdom third.

Oil Seeds

Most of the vegetable oils are obtained from the seeds or fruits of plants. These plants are of infinite variety, and grow in almost every type of climate. Each vegetable oil has its special uses, but in general, these oils are used in the manufacture of margarine, soap, candles, toilet requisites, varnishes, paints, etc. After the oil has been extracted the remaining pulp often has some commercial use. The pulp left after the extraction of cotton-seed oil from the cotton seed is used for making oil-cake for feeding animals. Linseed is similarly used.

LINSEED OIL.—This, of great value in the making of varnish, is, as its name suggests, obtained from the seed of the flax plant (see page 284). Argentina at one time was practically the sole supplier of world needs, but the government policy of buying very cheaply from the growers and selling at a high price on the world market has led, on the one hand, to farmers planting much smaller areas and, on the other, to increased production elsewhere and to the extensive use of substitutes. Production in the Argentine is now only a third of pre-war and is greatly exceeded by that in the

United States where it is grown in the spring wheat belt. World trade is considerably less than half that in 1938. Chief exporters (in thousands of tons): Canada, 40; India, 34; Argentina, 34; Uruguay, 30; United States, 24.

OLIVE OIL.– The olive tree is the characteristic plant of Mediterranean countries and where it has been introduced to Mediterranean regions outside Europe, the oil yield is less and the oil of inferior quality. The finest oil is produced in Italy (Lucca) and in the South of France. Spain and Italy are the largest producers, and Spain, Tunisia, Algeria, and Portugal the chief exporters.

GROUND-NUT OIL.—The ground-nut is more commonly known in England as the "monkey-nut" and in America as the "pea-nut". It will thrive on light soils of little use for other forms of agriculture, and its cultivation is widespread in many parts of the world. There have been no great changes in production in recent years except in the United States where yields are about twice what they were pre-war.

The average annual production of ground-nuts from principal producers (1955-6) in millions of tons is as follows: India, 4; China, 3·2; French Africa, 1; United States, 0·7; Nigeria, 0·7; Argentina, 0·2. World total, 12 million tons.

METALS

Except for gold, and to a very small extent silver, metals are not found native (*i.e.* uncombined) but in the form of chemical compounds, called *ores*, usually mixed with varying amounts of earthy impurities. Ores are *smelted*, or converted into metal, by various chemical processes and the resulting crude metal generally has to be purified or refined. These are large-scale industrial processes involving the use of considerable fuel and may or may not be carried out in the area or country in which the ore is mined. Ore mined in little-developed and non-industrialised countries is often exported as such but there is a growing tendency for smelting industries to develop in such areas.

Different ores of the same metal contain considerably different percentages of the actual metal and in the following tables the production figures for the various ores are expressed not in weight of ore but in weight of metal content. For each

metal there is a certain minimum mineral content below which it is not economically practicable to extract the metal.

Iron and Steel

Iron is the most important industrial metal and is also one of the commonest elements, accounting for about 5 per cent. of the earth's crust. It does not pay, however, to work ores containing less than 20 per cent. of metal. Production is increasing very rapidly in Canada and Venezuela. Some ores, *e.g.* those of Sweden, average as much as 60 per cent. of iron, those of Western Europe contain much less. A large amount of new iron and steel is obtained from scrap metal.

IRON ORE PRODUCTION, 1957
(Millions of Tons Iron Content)

United States	53	United Kingdom	5
U.S.S.R.	49	Western Germany	4
France	21	India	3
Sweden	12	Luxemburg	2
Canada	11	Algeria	2
Venezuela	10	Brazil	2

Most of the world's iron is converted into steel, a very strong alloy containing carbon. Steel may also contain varying amounts of other metals, such as manganese, nickel, cobalt, molybdenum, vanadium, and tungsten, according to the special purpose for which the steel is required.

STEEL PRODUCTION, 1957
(Millions of Tons)

United States	102	United Kingdom	22
U.S.S.R.	51	France	14
Western Germany	26	Japan	13

The U.S.S.R. produces half the world's manganese (4 million tons), and most of the remainder comes from Ghana, South Africa, Brazil, and India. Most of the world's cobalt and 90 per cent. of its nickel comes from Ontario, Canada. The United States produces 90 per cent. of the world's molybdenum (20,000 tons), and most of the remainder comes from Chile. Vanadium is obtained from the U.S.A., Peru, and South-West Africa. China and Portugal are the largest producers of tungsten, followed by the U.S.A., Bolivia, Spain, and Australia.

Copper

On account of its high conductivity, copper is used in large quantities in electrical apparatus. It also forms many useful

alloys, *e.g.* bronze, phosphor-bronze, brass, monel metal, delta metal, German silver, etc. World production has increased by over a third since 1939 and there have been big increases in the output from the United States, Belgian Congo, and Northern Rhodesia.

PRODUCTION OF COPPER ORE, 1957
(Thousands of Tons Copper Content)

United States	983	Japan ..	80
Chile ..	480	Mexico ..	60
Rhodesia .	332	Peru ..	58
U.S.S.R. ..	419	Australia ..	52
Canada ..	325	Yugoslavia ..	33
Belgian Congo	240	World Total	3,478

Lead

Lead is used as sheet lead for roofing, for pipes, for accumulator plates, and for alloys such as type metal, solder, and pewter. Despite its huge production, the United States imports 100,000 tons a year from other American countries. Exporters of lead include Australia, Mexico, Canada, Belgium, and France.

PRODUCTION OF LEAD ORE, 1957
(Thousands of Tons Lead Content)

United States ..	303	Peru .. .	130
Australia . ..	289	French Morocco ..	91
U.S.S.R.	279	Yugoslavia. ..	89
Mexico	213	Germany	79
Canada	163	World Total .	2,126

Zinc

Is used as a coating to prevent rust (galvanised iron), and in alloys such as brass, German silver, and delta metal. Australia, Canada, Italy, and Sweden, are the principal exporters of ore and Belgium, the United States, and the United Kingdom, the chief importers. World production has increased 25 per cent. since 1939. Much of this increase is due to the United States and Canada, but output has also been greatly increased in the Belgian Congo and Peru.

PRODUCTION OF ZINC ORE, 1957
(Thousands of Tons Zinc Content)

United States ..	468	Japan	134
Canada	369	Poland	112
Mexico	241	Italy .	110
Australia	247	Germany	94
U.S.S.R.	337	Spain . .	78
Peru	156	World Total .	3,173

Tin

Tin is used in large quantities for making tin-plate for food containers. It is also used for various alloys such as bronze, gun-metal, solder, and pewter. Most of the tin from South-East Asia goes to the United States. Great Britain imports about 25,000 tons, mainly from Bolivia. Tin mines in Cornwall have been worked since Roman times but are now nearly exhausted, present production being less than 1,000 tons a year.

PRODUCTION OF TIN ORE, 1957
(Thousands of Tons Tin Content)

Malaya	60	Belgian Congo .	14
Indonesia	28	Thailand . ..	13
Bolivia . ..	28	Nigeria	10
U.S.S.R.	(25)	World Total ..	200

Aluminium

Aluminium is the most abundant of the metals, making up some 8 per cent. of the earth's crust. Clay is an aluminium silicate but aluminium cannot at present be extracted commercially from this compound. It is obtained almost exclusively from the ore known as bauxite, which contains 25 per cent. of the metal. Aluminium has a wide variety of uses and various light but strong alloys such as magnalium and duralumin are used in aircraft construction. The extraction of aluminium from its ores requires the use of large quantities of electricity and hence this process is usually carried out where cheap hydro-electric power is available, *e.g.* at Foyers and Kinlochleven in Scotland. More than three times as much aluminium is used now as before the 1939-45 War.

BAUXITE PRODUCERS, 1957
(Thousands of Tons of Ore)

Jamaica . .	4,071	Hungary	893
Dutch Guiana ..	3,351	Greece . ..	843
British Guiana ..	2,078	Yugoslavia ..	781
France . ..	1,671	Malaya	329
United States .	1,426	Italy	259
U.S.S.R.	(1,200)	World Total	18,569

Most of the ore from Dutch Guiana goes to the United States, which also imports from Indonesia. Ore from British Guiana goes to Canada. The chief United Kingdom sources of supply are France and Ghana. Much of the aluminium

produced in the U.S.A., Japan, the United Kingdom, and Western Europe is obtained from scrap aluminium.

ALUMINIUM PRODUCERS, 1957
(Thousands of Tons)

United States ..	1,648	United Kingdom ..	145
Canada	558	Norway	105
U.S.S.R. ..	485	Japan	75
France	176	Italy	73
Germany (F.R.)	170	World Total ..	3,500

Gold

Gold differs from other metals in that it is found "native", *i.e.* uncombined. Because of its high value (one ounce of gold is worth over £12) it can profitably be extracted from rock containing only a very minute amount of metal. Nearly half the world's gold comes from South Africa.

PRODUCTION OF GOLD, 1957
(Value in £M Sterling)

Union of South Africa	213	Australia	13
U.S.S.R. . ..	125	Ghana	10
Canada	55	Rhodesia	7
United States	22	World Total	480

Silver

Silver sometimes occurs native and is often found in workable amounts in association with lead and copper ores.

PRODUCTION OF SILVER, 1957
(Thousands of Tons)

Mexico	1,340	Canada	895
United States ..	1,031	U.S.S.R.	760
C. and S. America	994	Australia	426

World Total: 6,091

Uranium

The naturally-occurring sources of uranium and other radio-active metals contain only very small amounts of metal and its extraction is a long and costly business.

PRODUCTION OF URANIUM, 1956
(Tons of Metal)

Union of South Africa	4,000	United States ..	2,000
Canada	2,500	Soviet bloc	4,000

Most of the South African metal is obtained by re-working rock already processed for gold. Canadian ore comes from

around Great Bear Lake, Lake Athabaska, and in the Blind River area of Ontario, and American ore from the Colorado plateau. Other producers include Belgian Congo, Portugal, Australia (Rum Jungle), and France (850 tons). Radium ore is found in the Belgian Congo and thorium in Madagascar.

Fertilisers

The use of fertilisers to increase agricultural yields has more than doubled since 1938. The three principal classes of fertiliser are those supplying nitrogen, phosphorus, and potash respectively. Ammonium sulphate, one nitrogen fertiliser, is a by-product of coal-gas manufacture and other nitrogen fertilisers can be synthesised in special plant.

Phosphorus fertilisers are prepared from various phosphate rocks, and potash fertilisers from naturally-occurring potassium salts. The famous Stassfurt deposits in Germany were, until recently, by far the largest source of potash.

PRODUCTION OF PHOSPHATE ROCK, 1956

(Thousands of Tons)

United States .	15,999	Nauru	1,491
Morocco.. ..	5,700	Algeria	606
Tunisia	2,077	Egypt ..	615
U.S.S.R... ..	(2,000)	World Total .	28,500

PRODUCTION OF POTASH, 1956

(Thousands of Tons)

Germany (West) .	1,965	France	1,500
United States .	1,930	U.S.S.R.	(1,200)
Germany (East) ..	1,556	World Total ..	7,300

Cement

Cement is manufactured by heating in kilns a mixture of clay and limestone. It is employed on a very large scale for building and constructional work of all kinds and especially for big industrial projects.

PRODUCTION OF CEMENT, 1957

(Millions of Tons)

United States ..	50	France	13
U.S.S.R.	29	United Kingdom .	12
Western Germany .	19	Italy.. .. .	12
Japan	15	Belgium	5

In addition to the above, Canada and India each produce nearly six million tons annually, and Poland, Spain, Sweden, and the Union of South Africa nearly four.

CHAPTER XXI

THE POWER RESOURCES OF THE WORLD

Introductory

The four principal sources of power are coal, oil, natural gas, and falling water. The latter has been utilised in modern times for the generation of hydro-electric power. Coal, oil, and natural gas are all wasting assets, the available reserves being gradually used up and never renewed. Undoubtedly, the power of the future will be obtained mainly from the almost inexhaustible supply of atomic energy. But there are still many engineering problems to be solved in the large-scale utilisation of atomic energy, and the building of the necessary power-stations and plant involves enormous capital outlay. Even in Britain, the first country to operate an industrial atomic energy plant, it is unlikely that the output of atomic energy by 1965 will be more than the equivalent of about fourteen million tons of coal.

In recent years the world has become more and more industrialised and the pace of industrialisation is still increasing, so that more and more fuel energy is required. Some idea of the increased demands can be obtained when it is realised that of all the coal mined in history, half has been mined in the last twenty-five years, and of all the oil mined in history half has been mined in the last *ten* years.

Oil, and the natural gas that is so often found with it, are the sources of energy the supply of which can be most rapidly and cheaply expanded. In 1913 nearly 90 per cent. of the world's power was obtained from coal. In 1956 the world's total industrial power was obtained as follows: coal, 43·5 per cent.; oil, 33·4 per cent.; natural gas, 14 per cent.; hydro-electricity, 7·5 per cent. These figures are heavily weighted by North America, which uses more than half the total industrial power of the free world and derives 40 per cent. of industrial power from oil, 30 per cent. from coal, 23 per cent. from natural gas, and 7 per cent. from hydro-electricity.

In the countries of Western Europe the bulk of industrial power is derived from coal, except in such countries as Norway, Switzerland, and Italy, which have abundant water

power and little or no coal. In Britain in 1957 the sources of power (expressed in millions of tons of coal equivalent) were coal, 208; oil, 38; hydro-electricity, 1·6.

Coal

The annual production of coal is nearly 1,500 million tons. This includes anthracite, bituminous coal, and lignite (brown coal of poor quality), but excludes the production of peat, which is of considerable importance in Ireland, Holland, and the U.S.S.R. Coal is important not only as a source of power, but also for the production of gas, chemicals, fertilisers, perfumes, aniline dyes, and a vast range of other by-products.

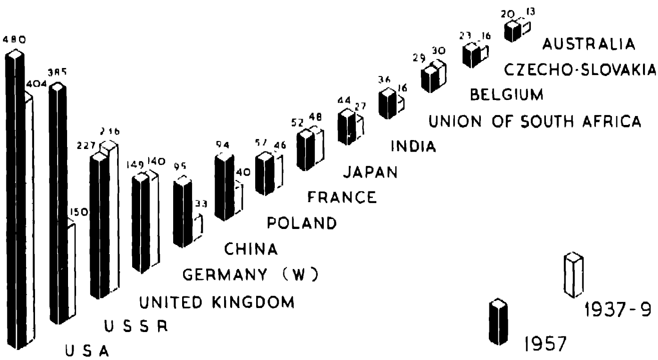


Fig. 161. World Production of Coal in Millions of Tons.

The distribution of active coal production differs markedly from the distribution of coal reserves, for many vast coal-yielding areas have not yet been extensively developed. There are large and almost untouched reserves in China, Central Canada, Western U.S.A. (Utah), and Siberia.

The leading producers of coal (1957) are shown on Fig. 161. The United States, the largest producer, is responsible for nearly one-third of the total output. Most American coal comes from the great coalfields of the eastern half of the country, viz. Pennsylvania, Virginia, Kentucky, and Illinois.

Europe supplies about one-half of the total output, the leading countries being the U.S.S.R., Britain, and Germany. German output, despite the loss of Silesian coalfields to Poland is now higher than it was in 1939. British production

fell during the war years and is still about 15 million tons less than pre-war. British exports of coal in 1939 were 40 million tons. In 1955 we exported about 10 million tons, worth £64 million, but only by importing an almost equal quantity from the United States at a much higher price. The United States is also exporting small but increasing amounts of coal to other European countries.

Poland is the largest European exporter. Production in the U.S.S.R. is now more than three times what it was in 1934 and eleven times what it was in 1913.

The remainder of the world (*i.e.* excluding Europe with Asiatic Russia and North America) accounts for less than

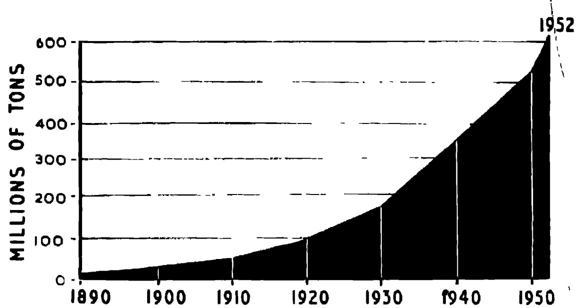


Fig. 162. World Production of Petroleum.
(World production in 1956 rose to 760 million tons.)

10 per cent. of the total world production, and much of this comes from India and Japan. It will be clear, therefore, that the countries of the Southern Hemisphere are relatively unimportant as coal producers. The principal coal-working areas of the southern continents are (*a*) in South Chile near Concepcion; (*b*) South Africa (Newcastle, Middleburg, and Wankie); (*c*) in Australia (Newcastle, Ipswich, and Collie); and (*d*) in New Zealand (Westport and Greymouth).

Mineral Oil

In 1850 very little petroleum was used, but to-day it is one of the "key products" of the world, being important for power, heating, lighting, and as a source of lubricating oils and many important chemical products.

The extraction of oil is an exhaustive industry. The opening of new fields may bring a country quickly into

prominence as an oil-producer, but the supplies may last only for a limited period. For instance, in 1921, Mexico, producing 30 million tons of oil annually, ranked second only to the United States, but in 1934 Mexico produced less than 6 million tons, and ranked seventh as an oil-producing country. The oil production of California has also decreased in recent years.

To-day, the U.S.A. is the leading producer of oil, being responsible for nearly half the total world output. The chief oil centres of U.S.A. are in Texas, Oklahoma, Kansas, and California. More than 100,000 miles of pipe-line are used to carry oil from the wells to the consuming areas and ports.

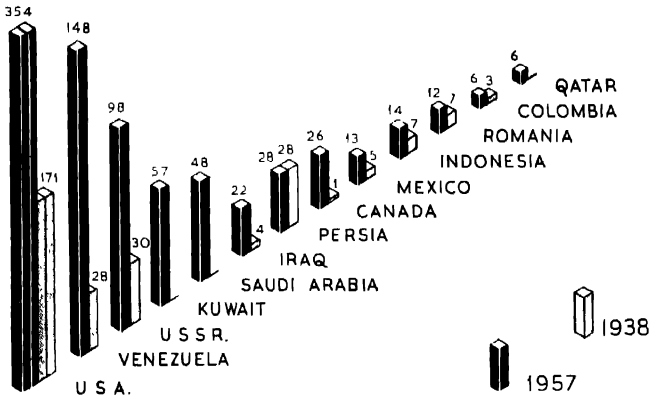


Fig. 163. WORLD PRODUCTION OF PETROLEUM IN MILLIONS OF TONS.

Venezuela, where oil production is a recent development, takes second place. The principal oilfields are in and around the Gulf of Maracaibo. It is fully expected that other rich oilfields will be found in South America.

Russia is the third producer of importance. The older Russian oilfields are situated at Baku (on the Caspian Sea), and at Grozny and Maikop to the north of the Caucasus Mountains, but two-thirds of Russian oil now comes from the newly-developed fields along the western edge of the Urals. Pipe-lines connect Baku and Grozny with the Black Sea, and others are being constructed to link the Ural fields with the industrial areas. The Roumanian oilfield is situated near Ploesti on the southern edge of the Carpathians.

The oilfields of Persia (Iran) are in the south-west of the country near Maidan-i-Naphtan. Deposits are also being worked further north on the borders of Iraq near Kirkuk. Oil from the latter fields is carried by pipe-line to the ports of Tripoli and Haifa on the Mediterranean coast. There have been spectacular post-war developments in two new oilfields on the west of the Persian Gulf, where the Saudi-Arabian fields and those in Kuwait are each producing over 50 million tons a year. The former are operated by American capital and the latter by joint Anglo-American control.

One of the most significant factors in world political and economic fields to-day is the greatly increased importance of the Middle East countries because of the enormous growth of the petroleum production of the Persian Gulf states. In 1956, these countries produced 166 million tons of oil, half the production of the United States. They contain two-thirds of the world's proven reserves of oil, and their share of total world output has risen from 6 per cent. in 1938 to 9 per cent. in 1946 and 21 per cent. in 1955. The Middle East oilfields are the main source of non-dollar crude oil for the refineries of Great Britain and Western Europe, and, indeed, of Asia and Australia as well. Vast sums of money are now being received as oil royalties by backward and undeveloped countries in the Persian Gulf, and the impact of this sudden wealth is producing many political, economic, and social problems.

Other oil-producing countries are Mexico, Indonesia (Sumatra, Borneo), Burma, Peru, Patagonia, Trinidad, and Canada. The output of the Canadian oilfields in Alberta, although relatively small is increasing rapidly. Pipe-lines have been constructed to refineries at Regina, to the shores of Lake Superior, and to Vancouver. The newly-explored oilfield in the Sahara is already producing 6 million tons a year, but its development by the French is handicapped by doubts as to the political future of French North Africa. Further south, French "Black Africa" is producing a further 6 million tons a year.

World oil production is now equal to demand.

A careful study of the distribution of the oil resources of the world will show that in many instances they occur very near to the fold mountain systems.

The distribution of oil in relation to the great shipping routes should be carefully noted. The Middle East and Indonesian supplies are easily available for the Mediterranean-Suez route (see also page 306); the American supplies for the trans-Atlantic routes; and the American, Mexican, and Venezuelan supplies for the Panama route.

Another point of interest is the distribution of oil in relation to the industrial regions. Of the four major industrial countries (viz. United States, Britain, Germany, and Russia), the United States and Russia have vast reserves of both coal and oil, while Britain and Germany have good supplies of coal but no oil deposits.

In the process of refining, crude petroleum is converted into a variety of marketable products. About half of the refined oil is sold as fuel oil and nearly a quarter as motor and aviation spirit. Other important products are bitumen, lubricating oils, and burning oils ("paraffin"). Refining is basically a process of fractional distillation and by modifying the conditions the proportions of the various products can be very appreciably altered to suit changes in demand.

Oil refining is a highly technical industry involving the use of large and costly plant. Hence refined petroleum products are considerably more expensive than crude oil.

The United States is by far the largest refiner of oil, handling 400 million tons, nearly two-thirds of the total world output. The Netherlands West Indies is second with 33 million tons. Before the war almost all the oil used in this country was imported from the U.S.A. already refined. Since the war, to reduce the strain on our dollar resources, a chain of oil refineries has been built in Britain to refine crude oil from the Middle East, and the United Kingdom by 1953 was the world's third largest refining country with 29 million tons, and is now an exporter of refined petroleum products to the value of £80 million. Until 1951 the refinery at Abadan, the largest in the world, supplied most of the refined oil for Asia and Australia. New refineries have now been built at Aden, in India and Australia, and elsewhere.

Within recent years, the petroleum industry in the United States has given rise to a very large-scale chemical industry for the preparation of valuable chemical derivatives from

petroleum, and similar production has now started in the United Kingdom, *e.g.* terylene at Wilton (Durham) and synthetic rubber at Fawley, and in other European countries.

Natural Gas

Natural gas is found in very large amounts in various oil-fields and especially in the United States. Formerly allowed to burn to waste, it is now conveyed, sometimes long distances, to towns and industrial areas, and provides about 14 per cent. of the world's total industrial power. In 1957 production in the main areas, in thousands of millions of cubic feet per annum, was as follows: U.S.A., 7,101; Canada, 576; Mexico, 247; Italy, 176; Venezuela, 127; Indonesia, 75; U.S.S.R., 26.

Water-Power

The use of falling water for the generation of hydro-electric power is even more recent than the use of oil for power. About one-tenth of the world's potential water-power has so far been harnessed, almost entirely in regions of advanced economic development. The natural conditions favourable to the development of hydro-electric power are:—

(*a*) Heavy rainfall evenly distributed throughout the year, so that the rivers will maintain a constant flow.

(*b*) An absence of very cold winter temperatures so that the rivers do not freeze.

(*c*) High mountains, so that the rivers will flow swiftly. Rapids and waterfalls are especially advantageous.

(*d*) Lakes, which act as reservoirs and help to maintain an even flow of the rivers.

In many parts of the world these natural advantages are almost entirely unused. For instance, Africa, especially in the Congo region, possesses the greatest potential power resources of any continent, but they are practically undeveloped. In the future, hydro-electric power may be used to exploit the vast mineral resources (copper, iron, phosphate, gold, asbestos, etc.) of this continent. Next to Africa, Asia has the greatest resources of potential power, and there are great potential power resources also in South America, in the Andes, and the Brazilian and Guiana plateaux.

More than 95 per cent. of the total output of hydro-electric power is concentrated in North America and Western and Central Europe, though the greatest single centre in the world is at Dnieprostroi on the river Dnieper in Southern Russia.

The principal countries in which hydro-electric power is used are United States, Norway, Newfoundland, Canada, Switzerland, Sweden, Italy, France, Russia, New Zealand, Japan, Chile, Germany, Brazil, and Britain. Many of these countries, *e.g.* Norway, Sweden, Switzerland, and Italy, have practically no coal and use electricity as the basis of their industrial development. Cheap hydro-electric power is often

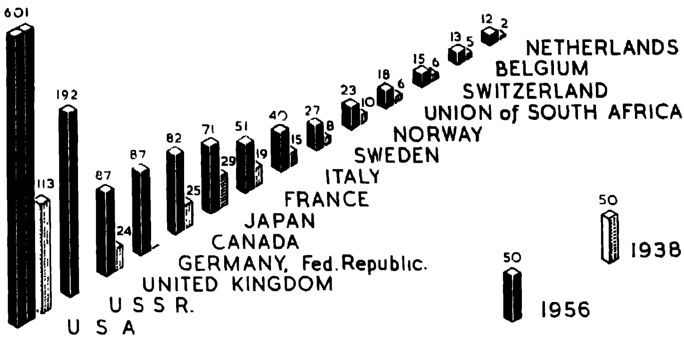


Fig. 164. PRODUCTION OF ELECTRICITY IN THOUSAND MILLION KWH.

used for (*a*) electric railways, (*b*) the manufacture of aluminium, and (*c*) the pulping of wood for newsprint. Taking Europe as a whole, coal now supplies less than two-thirds of the industrial power used, as against nearly three-quarters in 1938. Based on the *per capita* consumption, Norway, Canada, and Switzerland are by far the most lavish users of electricity, but the United States has actually a very much greater output than any other country.

In almost all countries there has been during the last fifteen years a very great increase in the amount of electricity used for domestic and industrial purposes, on account of its greater convenience and, in many cases, of its greater economy (see Fig. 164). Taking the world as a whole, some two-fifths of the electricity generated is obtained from water-power.

CHAPTER XXII

WORLD COMMUNICATIONS
OCEAN ROUTES

Routes of the Atlantic Ocean

In some atlases there are maps which show the main trading routes of the world by lines of varying width. Such maps clearly show that the greatest of all sea routes is the North Atlantic route between North-West Europe and North America, two densely-populated, highly-developed, industrialised regions. The American end of this route has various termini. The greatest amount of shipping goes to the New England ports, and to New York, Philadelphia, Baltimore, etc. But in summer the St Lawrence route is open, and the main North Atlantic route lies further north using the short "great circle" route (page 47) which passes north of Newfoundland. The great bulk of trade is eastward bound, and consists of timber, wood pulp, wheat, meat, iron-ore, etc.

Since both Eastern North America and North-West Europe are manufacturing areas the trade in manufactured goods is smaller than the trade in food and raw materials. The westward bound cargo is therefore less than that carried eastwards. This route carries more passenger traffic than any other sea route, and it is served by the largest and most luxurious liners of America, England, France, Germany, and Italy.

The group of Atlantic shipping routes spreads out fan-wise from Europe to the West Indies and Panama and to the Canaries (a fuelling station) whence there are two lines of trade, one south-westwards to South America (to Rio and Buenos Aires), and the other south-eastwards to Cape Town. Another group of routes radiates from the New York region to the Mediterranean, South Africa, Eastern South America, and Panama.

A striking feature of Atlantic trade routes is the absence of a counterpart to the Europe-America route in the Southern Hemisphere. Because temperate South Africa and Argentina produce very much the same food products and raw materials,

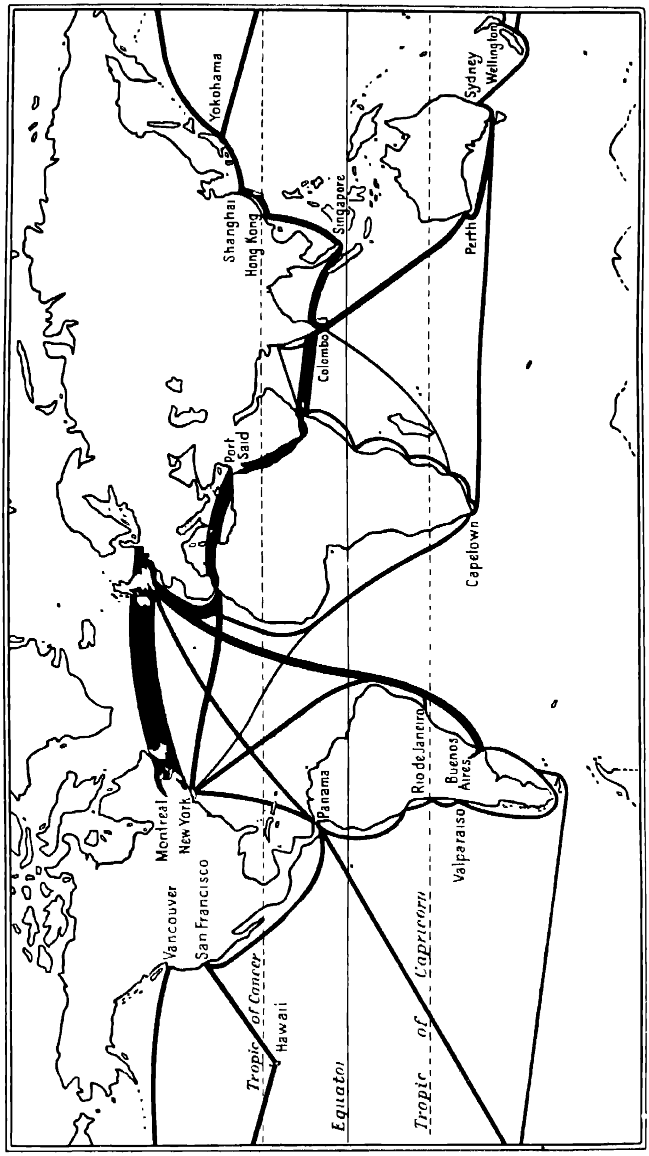


Fig. 165. THE CHIEF OCEAN ROUTES OF THE WORLD.

there is little scope for interchange and trade. The trading associations of these two areas are with Europe and America, where they can sell their surplus food and raw materials, and whence they can obtain manufactured goods.

The Mediterranean-Suez Route

The map of world trade routes shows that the Mediterranean-Suez route to the East, to Australia, and to East Africa ranks next in importance to the North Atlantic route. This great route passes through the heart of the Old World, and ships following it can call at more ports and serve more peoples than on any other route. There are a large number of refuelling stations, *e.g.* Gibraltar, Malta, Port Said, Aden, and Colombo, so that ships can refuel frequently and thus carry more cargo. The passenger traffic on this route is not sufficient for the economic use of such large liners as are employed on the North Atlantic route, nor could these latter use the canal as it is at present, although the canal could be, and no doubt would be, deepened if the need arose. Practically all the European and much of the American traffic for India, the East Indies, China, and Japan, passes through Suez, but despite this, two-thirds of the total traffic consists of oil tankers to and from the Persian Gulf.

With the construction of oil pipe-lines to the Mediterranean it seemed likely that oil traffic through Suez would decrease, but owing to the enormous increase in output from the Persian Gulf (Kuwait and Saudi Arabia) the reverse has, in fact, been the case. The north-bound tankers are carrying crude oil for British and European refineries and the south-bound tankers are either in ballast or carrying refined petroleum for Asia and Australia. With the re-opening of Abadan and the construction of new refineries at Aden, in India, and in Australia, there is now less need for European refined oil to go south again.

The outward traffic to Australia through Suez is principally that of passengers and mails. The Suez tolls are high, therefore cheaper fares, both for emigrants and goods, make the Cape route the more important for trading ships going out to Australia. These fuel at Cape Town and proceed to Australia backed by the strong west winds of the south temperate zone. Sailing ships always use the Cape route to Australia, and take

advantage of the westerlies in the South Indian Ocean. Ships returning from Australia follow three routes:—

(1) Sailing ships proceed eastwards across the South Pacific, and, backed by the westerly winds, reach Europe via Cape Horn and the Atlantic Ocean. There are now very few ocean-going sailing ships left.

(2) Some ships travel back from Australia via South Africa. Then they take a route slightly more northerly than on the outward journey, in order to avoid steaming in the teeth of the westerly winds.

(3) At least 50 per cent. of the homeward-bound ships from Australia return via Suez. The products which they carry, principally wool, wheat, and meat, are sufficiently valuable to go by the shorter but more expensive route.

The Routes of the Pacific Ocean

The sea routes of the Pacific are of much more recent origin than the others already described. There is a route from Western North America to China and Japan which is in some ways a parallel to the North Atlantic route. Raw silk and tea from Japan and sugar from Hawaii are carried eastwards to America, the return cargo being mainly timber and manufactured goods, and in recent years food products also. The Pacific routes converge on four main points: (1) Western America (Vancouver and San Francisco); (2) Panama; (3) China, Japan, and the East; (4) Australasia.

An important feature of the Pacific routes is the use of the Panama-New Zealand route for fast passenger traffic from the east of U.S.A. and from Europe. As in the South Atlantic, there is no really important east-west route in the South Pacific, because Australia and South America have few goods to interchange.

The two great east to west ocean routes of the Northern Hemisphere form part of a "girdle" of land and sea routes, viz. North-West Europe and Eastern America by sea; Eastern America to Western America by transcontinental railways; Western America to Eastern Asia by sea; Eastern Asia to Europe by the Trans-Siberian railway. There is no counterpart of this "girdle" of routes in the Southern Hemisphere (see also page 310).

Panama v. Suez

Before the opening of the Panama Canal in 1914, America's shortest sea route between the ports of her eastern and western coasts was via Cape Horn. Ships sailing from ports of North-West Europe to the west of South America had to take a similar course. The opening of the Panama Canal has benefited the American ports and trading facilities considerably, and the ports of Western Europe have benefited also, but to a lesser extent. The Panama Canal carries each year about one-third the cargo tonnage of the Suez Canal.

The main results of the opening of the canal are summarised below:—

(1) The route from *England to New Zealand* is slightly shorter by Panama than by Suez, but the route to Sydney is shorter via Suez. The Suez route has the advantage of touching more countries and having therefore greater advantages in respect to the collection both of cargo and passengers. The Panama route to New Zealand is therefore used primarily for quick mail and passenger transport.

(2) Although Panama does not shorten the route from *England to Australia*, it does shorten the route from the ports of Eastern America to Australia.

(3) The ports of *Eastern Asia* are still nearer to European ports via Suez, so that in this respect the Suez route is not affected. However, all ports from Hong Kong northwards and eastwards (*e.g.* Shanghai, Manila, Yokohama) are nearer to New York via Panama than by Suez. Therefore much American trade to the Far East is not carried via Panama, for American ships trading with India and Asiatic ports west of Hong Kong will use the Suez route, both because of the lesser mileage and because of the greater trading facilities the Suez route offers.

(4) The *western seaboard of both North and South America* is brought nearer to the ports of both Eastern America and Western Europe. This is one of the greatest advantages of Panama, since it has helped to develop the trade of the western states of South America. British Columbia now exports grain, timber, and other bulky commodities by a

cheap "all-water" route instead of by the expensive trans-continental route as before.

(5) As far as the *United States* is concerned the greatest advantage lies in the shortening of the sea route between her eastern and western coasts not only for trading purposes but for strategic reasons. The ships of the American navy can now be moved much more quickly from the Atlantic to the Pacific and vice versa, as political needs demand.

(6) The use of the Panama route will have a beneficial effect on the *West Indies* which now lie on a great ocean highway, instead of being, as formerly, the terminus of a sea route.

AIR ROUTES

A natural limit is set to the length of great land and sea routes by the extent of the continents and oceans. It would appear at first that there is no such natural limit to air routes. In the early days of long-distance flying, however, the relatively short range of aircraft led to air routes being planned to avoid: —

(*a*) Large stretches of ocean. Air routes took the shortest sea crossings, as far as possible keeping to the land and to chains of islands.

(*b*) High mountain areas where cloud, poor visibility, or ice formation on aircraft, may make flying dangerous in bad weather.

(*c*) Extensive forest areas where landing is obviously difficult.

Thus those very barriers that impede man's progress on land were effective in limiting his choice of air routes. Owing to the great improvement in aircraft performance and reliability, there are now no areas where the choice of a route is limited by purely physical features.

The main factors influencing the selection of routes to-day are ground facilities and sufficient traffic for economic working. The operation of modern aircraft demands much assistance from the ground in the way of air traffic control, radio aids to navigation, meteorological services, suitable runways and airports, passenger-handling and Customs facilities.

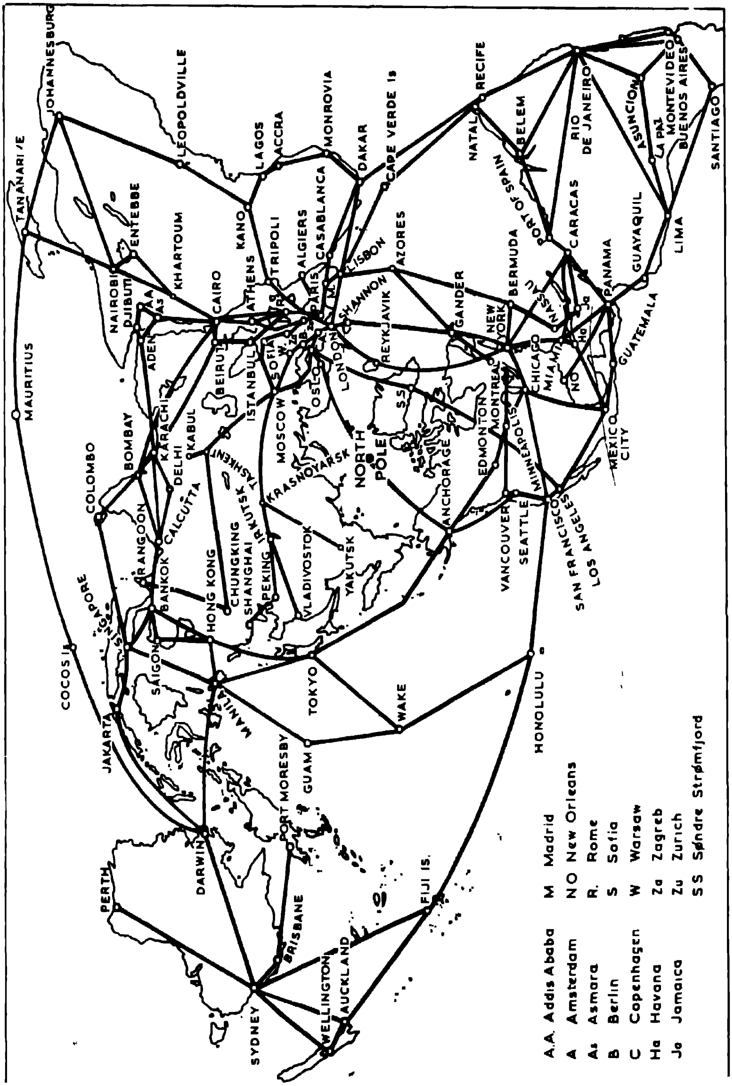


Fig. 166. Principal World Air Routes.—Note the east-west girdle in the Northern Hemisphere. The map is on a polar equidistant projection with modified extensions interrupted for the Southern Hemisphere. These enable the southern continents to be shown reasonably well, but the east-west ocean distances between them are greatly exaggerated.

and proper maintenance. Because these services are naturally more readily obtainable in the more densely populated areas, and because these same areas are those in which the demand for air services is greatest, the main air routes still often continue to avoid areas of scanty population.

With the increase in number of airports with suitable facilities all over the world, it is comparatively simple to substitute a new route for an old one, and switches are constantly being made for traffic reasons to simplify particular services. Over many of the busiest routes there are slow services with many stops, and fast services with a minimum of stops. In comparing times it should be borne in mind that on some long flights passengers may spend one or more nights in hotels *en route*, although this is becoming most unusual.

Air transport is, in general, expensive for goods, unless these are of high value for their weight (*e.g.* air mail) or are urgently required (*e.g.* spare parts). Nevertheless the total value of goods imported into and exported from the United Kingdom by air in 1954 was more than £120 million.

The pattern of world air routes tends more and more to follow a regional design rather than a radiation of spectacular routes from one or two points of origin. The following notes give an outline of the general scheme, from the point of view of an observer in the British Isles:—

1. The North Atlantic and North America

There are direct routes from London to New York and to Montreal and others via Prestwick (Scotland), or Shannon (Eire), and Gander (Newfoundland). If weather is bad on the direct route, aircraft can fly via Iceland. There are direct routes from London to Caracas, one via Bermuda, Barbados, and Port of Spain, and the other omitting Barbados. The West Indies are also served via Gander or New York.

The Canadian Pacific Airlines route from Vancouver to Amsterdam calls at Edmonton, and the Scandinavian Airlines route from Copenhagen to Los Angeles at Sondre Stromfjord on the west coast of Greenland just inside the Arctic Circle. A new Scandinavian Airlines route from Copenhagen to Los Angeles and Tokyo via Anchorage (Alaska) passes directly over the North Pole.

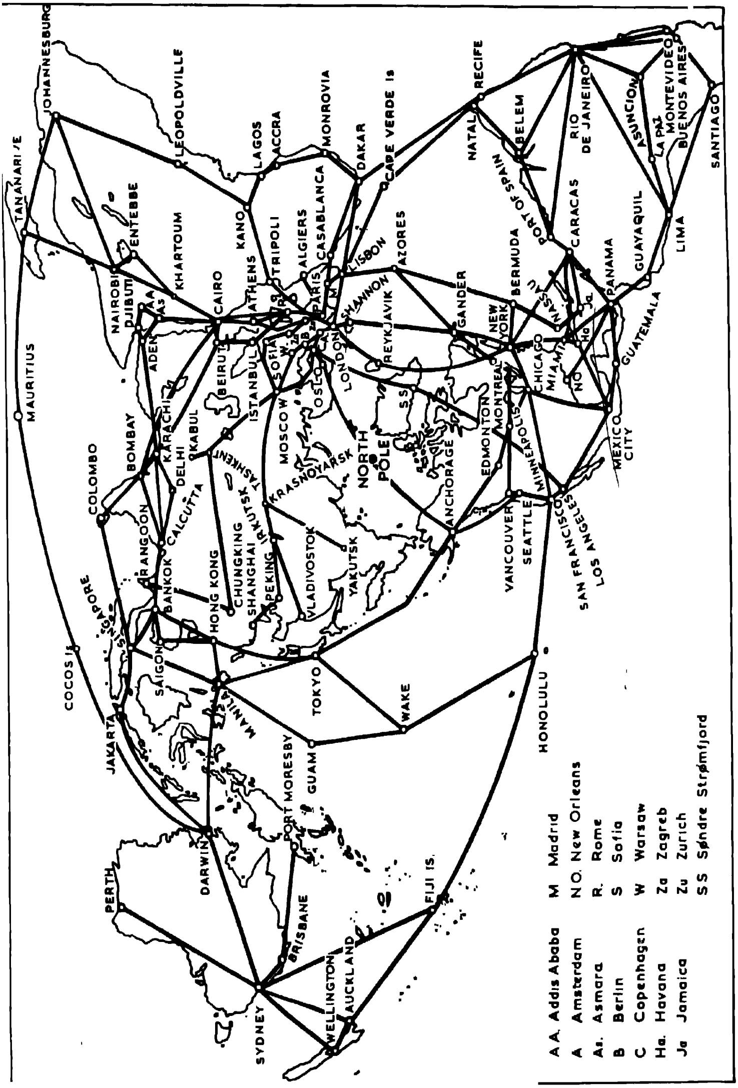


Fig. 166. PRINCIPAL WORLD AIR ROUTES.—Note the east-west girdle in the Northern Hemisphere. The map is on a polar equidistant projection with modified extensions interrupted for the Southern Hemisphere. These enable the southern continents to be shown reasonably well, but the east-west ocean distances between them are greatly exaggerated.

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2. The South Atlantic and South America

There are no B.O.A.C. routes to South America, but there are Brazilian and Argentinian services from London via Paris, Lisbon, Dakar, Natal or Recife, Rio de Janeiro, and Buenos Aires, crossing the Andes to Santiago. There are connections at Dakar for Bathurst, Freetown, and Accra in West Africa.

There is considerable air traffic between North and South America. An important development is the setting up of internal networks in such countries as Colombia, which are poorly served by other forms of transport.

3. Europe and the U.S.S.R.

Most of the capital cities of Europe have become the centres of networks connecting them with other key towns. London, Paris, Brussels, Amsterdam, Prague, Rome, Athens, and Moscow are particularly important in this respect. Many British services on the Continent are operated by British European Airways Corporation, but some by independent companies.

The Soviet network centres on Moscow. The main trans-continental route from Moscow to Vladivostok (40 hours) is via Kazan, Sverdlovsk, Omsk, Novosibersk, Krasnoyarsk, Irkutsk, and Chita, *i.e.* along the Trans-Siberian Railway. From Krasnoyarsk there is a service to Kirensk and Yakutsk, and from Irkutsk one via Ulan Bator to Pekin and Shanghai.

Another main route from Moscow is via Tashkent and Alma Ata to Sian, and thence to Pekin or Chunking. From the latter there is a service to Mandalay and Rangoon. From Tashkent one can fly to Kabul.

4. The Middle East

The trunk routes to the East and to South Africa mostly pass through the Middle Eastern countries in which Cairo, Baghdad, and Beirut are the main airports. Regional networks are operated in most of the Middle East states, many of them with British, and some with American, backing. Most of the key towns (*e.g.* Teheran, Baghdad, Ankara, Damascus, etc.) are linked not only with each other, but also with the rest of the world, more closely than ever before.

5. India, the Far East, and Australia and New Zealand

The main B.O.A.C. routes are London—Zurich or Rome—Beirut, and thence to Karachi, either direct or via Bahrain, Kuwait, or Teheran. Karachi in West Pakistan is one of the principal airports of the Indian sub-continent and has trunk routes to the chief cities of India and to Dacca, the capital of Eastern Pakistan.

To the Far East the main route is Karachi—Calcutta—Rangoon or Bangkok—Hong Kong—Tokyo. Tokyo is only thirty-nine hours from London by Britannia, and the new Comet 4 pure-jet aircraft will soon be reducing this to thirty hours.

Routes to Australia proceed from Karachi via Calcutta to Singapore and Jakarta (Indonesia), and thence via Darwin or Perth to Sydney. From Sydney, Tasman Empire Airways have routes to Auckland and Christchurch.

Australia, a country of great distances and widely separated centres of population, has a very important network of internal air lines. There is also a highly-organised flying doctor service, bringing emergency medical aid to small and remote settlements.

6. Africa

The main routes to South Africa are via Rome and thence to Khartoum, and from Khartoum via Entebbe or Nairobi to Salisbury and Johannesburg. The journey time from London to Johannesburg by Britannia turbo-prop airliner is twenty-one hours fifty minutes.

Another important route is from London via Rome or Barcelona to Kano (Nigeria), and thence to Ghana and the West African colonies of Sierra Leone and Gambia. The Belgians operate from Brussels through Kano to Leopoldville in the Belgian Congo, from whence it is possible to get to South Africa, Rhodesia, or East Africa. There is an American route from Dakar via Accra and Leopoldville to Johannesburg.

7. The Pacific

Services across the Pacific are as yet less frequent than elsewhere, and follow fairly rigid routes. There are American services from San Francisco and Los Angeles via Honolulu to Wake Island and thence to Tokyo, or via Guam and

Manila to Saigon and Singapore. Another American route goes via Honolulu, Canton Island, and Fiji to Sydney or Auckland, and Qantas Empire Airways operate from New York via San Francisco and Honolulu to Sydney.

B.O.A.C. plans to inaugurate a round-the-world route in the spring of 1959. It will operate across the Atlantic and the American continent and traverse the Pacific to Tokyo, returning to Britain by way of Hong Kong, India, Pakistan, and the Middle East.

Notice that there is no intercontinental girdle south of the equator, but there is a Qantas service from Sydney via Perth, Melbourne, the Cocos Islands, and Mauritius, to Johannesburg.

TRANSCONTINENTAL RAILWAYS

The chief function of these railways is to provide quick transport across the continents from ocean to ocean. Since carriage by land is more expensive than carriage by sea, transcontinental railways are rarely used for the "through" transport of bulky commodities, though such goods (*e.g.* wheat, metal ores, etc.) are carried by rail from the producing regions to the coast. Through traffic on these routes is mainly concerned with the transport of passengers, mails, perishable goods, and articles of high value and small bulk.

In the Northern Hemisphere, the transcontinental railways are an integral part of the great east to west "girdle" of communications (see page 307). There is no counterpart of this girdle of routes in the Southern Hemisphere, for

(1) The continents are narrower.

(2) Most of the really important ocean routes lead northward to the densely populated areas of Europe and North America.

(3) There is little trade between South America, South Africa, and Australia because of the similarity of their productions.

North America

In North America there are several railways crossing the continent from east to west. Though they are all referred to as "Transcontinental Lines", those of the United States

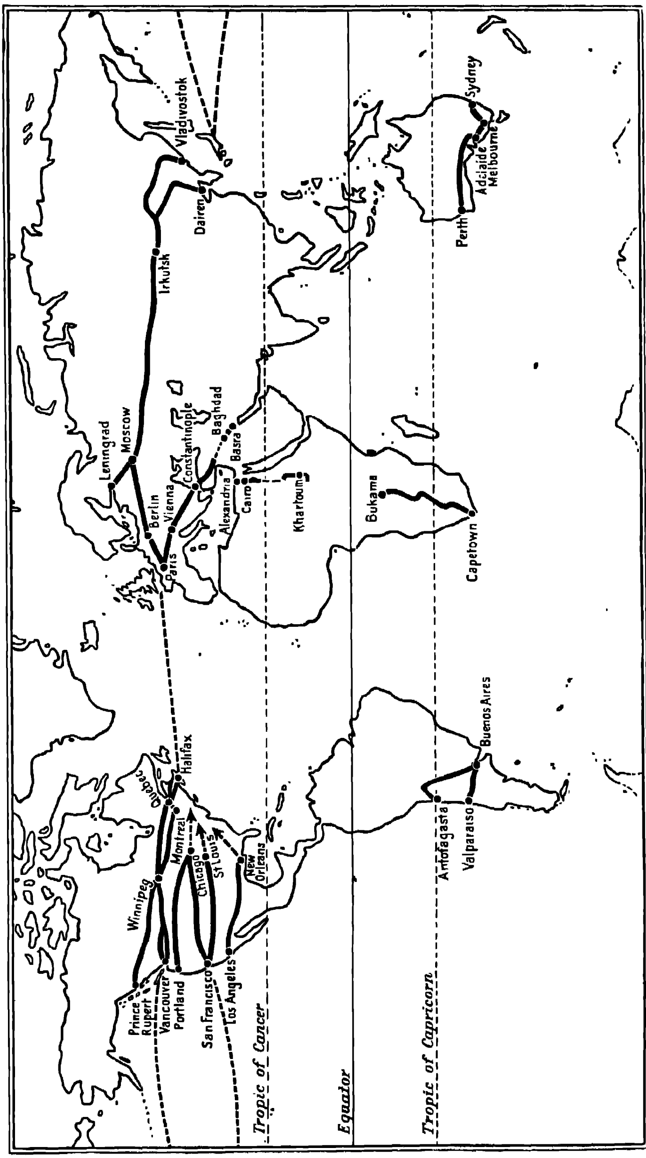

Fig. 167. Transcontinental Railways with Northern Sea Routes Indicated to Show the "Girdle" of Communication in the Northern Hemisphere.

lose their identity as such to the east of the Mississippi, where they merge into the railway network of the Eastern U.S.A.

The transcontinental routes of North America are:—

A. CANADA.—(1) The Canadian Pacific Railway, completed in 1885, which was primarily built to link British Columbia with the eastern provinces of Canada. It joins Halifax and St John (N.B.) with Montreal, Winnipeg, Regina, and Medicine Hat, where the main line divides. One branch proceeds via Crow's Nest Pass to Vancouver and the other via the Kicking Horse Pass and the Frazer Valley to Vancouver.

(2) The Canadian National Railway which links Moncton, near the head of the Bay of Fundy, with Quebec, then takes a more northerly route than the C.P.R. to Winnipeg, and thence to Edmonton, and via the Yellowhead Pass to Prince Rupert and Vancouver.

B. THE UNITED STATES.—(1) The Great Northern Railway, linking Duluth and Seattle.

(2) The Northern Pacific Railway, which joins Chicago, St Paul, Bismarck with Tacoma and Portland.

(3) The Union Pacific Railway, running from Chicago to Omaha, Ogden, and San Francisco.

(4) The Santa Fé Railway, which links St Louis, Kansas City, Sante Fé, and Los Angeles.

(5) The Southern Pacific Railway, passing from New Orleans to Los Angeles.

The North American transcontinental railway routes provide quick transport between the Atlantic and Pacific coasts, and were of very much greater importance before the opening of the Panama Canal, which provided a cheap water route between the two coasts. The railways are primarily concerned with passenger and mail traffic. The chief goods carried across the continent are fruit and films from the western states eastward, and manufactured goods of high value westward. Such commodities as raw silk and tea from the East also form part of the eastbound merchandise.

Eurasia

The outstanding transcontinental routes of Eurasia are:—

(1) The Orient Express route, which links Paris, Vienna,

Belgrade, and Istanbul (Constantinople). It has been continued across Asia Minor and will ultimately provide a through route from Paris to Basra on the Persian Gulf. This railway provides communication between the densely populated lands of South-East Asia and North-West Europe, but most people travel by air these days.

(2) A great west to east route which follows the lowlands of Central Europe and Northern Asia from Paris to Vladivostok. The western portion of this route runs from Paris, through Cologne, Berlin, and Warsaw to Moscow. The eastern section, known as the Trans-Siberian Railway, runs from Leningrad and Moscow across the Siberian lowlands to Vladivostok. This railway, completed in 1905, was constructed primarily to provide quicker communication between the centre of government in European Russia and the remote and isolated Russian territories bordering the Pacific. There is now a through route from the Trans-Siberian Railway to Peking, the capital of Communist China. A second Trans-Siberian Railway is now being built between Kuibyshev and Irkutsk, more or less parallel to the first but on a more southerly route.

While the Trans-Siberian Railway has been of undoubted value in helping to open up the isolated areas of Central Siberia, its value as a "through route" must not be over-estimated. Like the American transcontinental railways, its through traffic is practically confined to the transport of passengers, mails, and urgent or other valuable goods. Bulky goods can be carried more cheaply by the Suez route.

(3) The Russian territories are now linked to the Persian Gulf ports. This route proved of great value for supplying the U.S.S.R. during the war, but is now little used.

South America

Buenos Aires is connected by railway to Valparaiso, giving a quick alternative to the long voyage via the Magellan Straits.

A second route runs from Buenos Aires north-westward to Tucuman and thence across the Bolivian plateau to Antofagasta in North Chile. It is extremely doubtful whether

this route will ever be of much importance for "transcontinental" traffic.

Africa

The still uncompleted Cape to Cairo railway is an impressive enterprise originated by Cecil Rhodes. Its aim was to link the railways of Egypt and the Sudan with those of South Africa. Unlike the Trans-Siberian Railway it does not tap vast and remote landlocked areas, but is paralleled by cheaper sea routes both on the east and west. Its main function, to-day, seems to be to link the termini of shorter lines running inland from ports on the east and west coasts. Its terminus, Cape Town, is not the beginning of other important routes by sea, and so is virtually a "cul de sac". Little merchandise is carried between Johannesburg and Cape Town, for the majority of ingoing and outgoing goods use the lateral railways to Lourenço Marques or Beira on the east. The Katanga region of Belgian Congo and Northern Rhodesia have a similar outlet to Benguela or Lobito Bay on the west. This route opens up prospects for the development of the Portuguese territory of Angola.

Australia

A spectacular transcontinental railway, crossing over 1,000 miles of desert, links South-East Australia with Perth in Western Australia. This railway was built by the Australian Government so that West Australia could be more closely linked with the other states for political purposes. Like the Cape to Cairo railway it is paralleled by a sea route, and so has little goods traffic. Long-distance rail traffic is complicated by the fact that there are three different gauges in use in the different states, necessitating change of trains. Part of another transcontinental line, to link Darwin with Adelaide, has been constructed, and the Stuart Highway links the ends of the unfinished section from Alice Springs to Birdum. But the rapid developments in aviation may cause the abandonment of railway construction across sparsely-peopled areas in favour of air transport. Darwin now has regular air services to all the other state capitals.

CHAPTER XXIII

WORLD DISTRIBUTION OF POPULATION

Some Factors Affecting the Distribution of Population

A map showing the density of population throughout the world reveals the fact that human beings are very unevenly spread over the earth's surface. Most people congregate where natural and other conditions most easily provide a means of earning a livelihood, and they shun those areas which present difficulty in so doing. Relief, climate, vegetation, and accessibility all help to limit man's activities. The *tundra* is too cold and remote, and is only inhabited by scattered tribes of nomads. *Forest* regions, both in the temperate and hot zones, impose limitations on settlement, and are usually only inhabited by scattered groups of trappers and lumberers in the temperate zone, and by wandering, half-civilised hunting tribes in the hot, wet parts of the globe.

Hot deserts, too, are scantily peopled, unless mineral wealth lures adventurous seekers to settle in spite of the shortage of food and water, as in the deserts of Western Australia and in the inhospitable climate of the Yukon goldfields. Irrigation schemes make the cultivation and settlement of limited areas of the deserts possible, as in Egypt, Mesopotamia, portions of the deserts of Western U.S.A., and the fertile river valley strips of the Peruvian Desert.

Mountains, except where mineral wealth attracts, or where they provide cooler conditions as a relief from the heat of the neighbouring plains, are scantily peopled because of their ruggedness, unfavourable climate, difficulties of transport, and the limitation placed upon agriculture. Inaccessible plateaux like Tibet have few people, but on the other hand, the cool plateaux of the Andes (Peru, Ecuador, etc.) have a greater population than the hot forested plains of the Amazon.

The regions of densest population in the world are either regions of great industrial development, or regions of intensive and scientific agriculture.

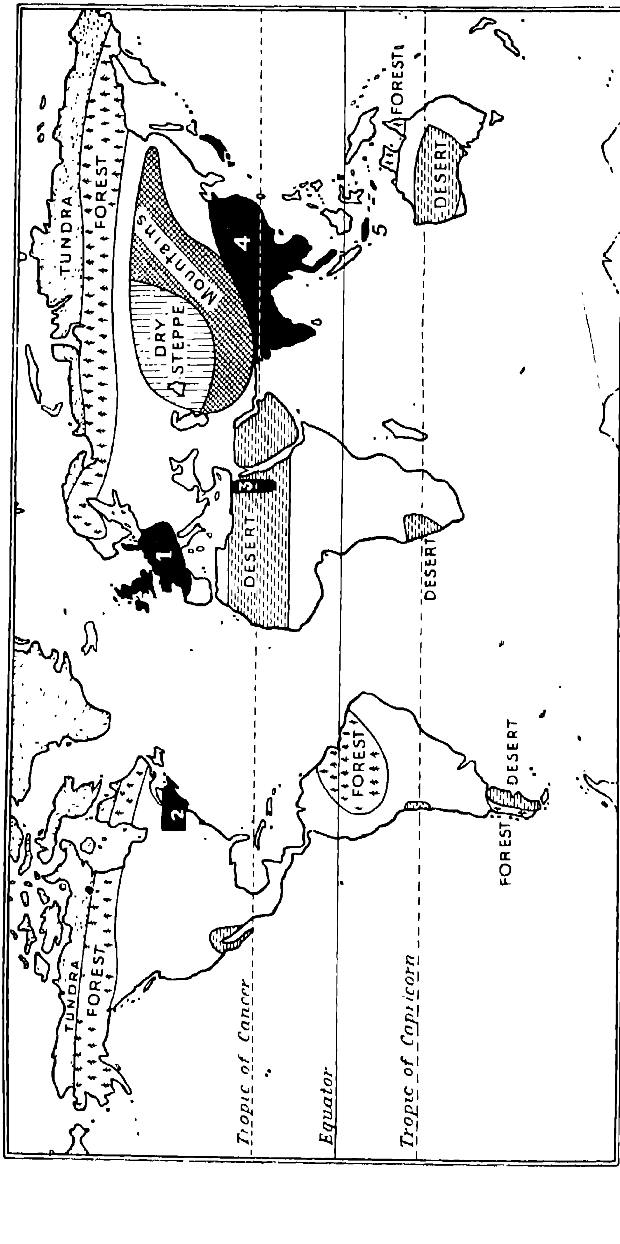

Fig. 168. World Regions of Dense and Scanty Population.
Areas shown in black are areas of dense population. For key to numbers see page 321.

Manufacturing Areas

In this and the following section the numbers (1) to (5) refer to Fig. 168 on page 320.

(1) The greatest manufacturing region is in the north-west of Europe, which includes the highly industrialised areas of Britain, Belgium, North-East France, and Germany. The densest population is found on the coalfields. Agriculture in these regions is also of an intensive and scientific type. Holland, with more than 800 people per square mile, is the most densely populated country in Europe. The northern plain of Italy, intensively cultivated, and with many large industries using hydro-electric power, is another European area of dense population.

(2) Another great manufacturing region with a dense population is in the north-east of U.S.A., a belt extending from Chicago eastwards, south of the Great Lakes, through the Pennsylvanian coalfield to New York and the New England States.

Densely Populated Agricultural Areas

Regions with a very dense population dependent on agriculture are:—(3) Egypt, (4) South-East Asia, (5) Java.

Egypt is densely populated along a narrow strip on both sides of the River Nile. This is an oasis land where the possibility of two and three crops per annum as a result of climatic and soil conditions gives a high agricultural return, and consequently supports many people. Moreover the Nile Valley is a region of long historical development.

In the countries of South-East Asia, viz. Japan, China, India, Siam, and French Indo-China there are both densely and sparsely peopled regions. The alluvial river basins, viz. Ganges, Si-Kiang, Yangtse, etc., are all thickly peopled, but mountainous zones and dry areas such as the Thar Desert support very few people.

Java, an island in the equatorial zone, with well organised plantations and a rich volcanic soil, is one of the most densely peopled areas in the world, with 785 people per square mile.

CHAPTER XXIV

TOWN SITES

The Influence of Rivers

People tend to congregate at the meeting-place of natural routes. Also one of man's main considerations in making a settled home is a good water supply. Remembering that river valleys are nature's "easy ways" or routes across a country, the most likely place for man to settle was by a river, because here he had both water supply and ease of communication.

Most of the "old" towns of the world are situated by rivers, though many of the larger towns are not, for they have grown up on coalfields during the industrial development of the last century.

Some river situations have more advantages than others, and the more important types of river sites are enumerated below:—

(1) The confluence of two rivers. Here three valleys meet and a town develops, *e.g.* Coblenz (Lat. *Confluens*), where the River Lahn and the River Moselle join the Rhine; Oxford, at the confluence of the Cherwell and the Thames; St Louis, at the confluence of the Mississippi and Missouri; Khartoum, at the confluence of the Blue and the White Nile; Allahabad, at the confluence of the Jumna and Ganges; and Wu-Chang, formerly Hankow (kow = mouth), at the confluence of the River Yangtse-Kiang and the River Han.

(2) The bend of a river, *i.e.* where the river changes its direction, *e.g.* Sheffield (Don), Orleans (Loire), Kaifeng (Hwang Ho), Stalingrad (Volga).

(3) The lowest bridging point, which is often the head of the estuary and the limit of ocean navigation, *e.g.* London, Rouen, Hamburg.

(4) A ford, which is a place where the river is shallow enough to be crossed without difficulty, *e.g.* Bedford, Worcester.

(5) The limit of navigation. London Bridge is the limit of navigation for ocean vessels, as is Wu-Chang on the Yangtse-Kiang. Oxford is the limit of navigation of the Thames by river steamer; Bedford is the limit for small river craft on the Ouse. In Roman times York was the limit of navigation on the York Ouse for grain-carrying vessels.

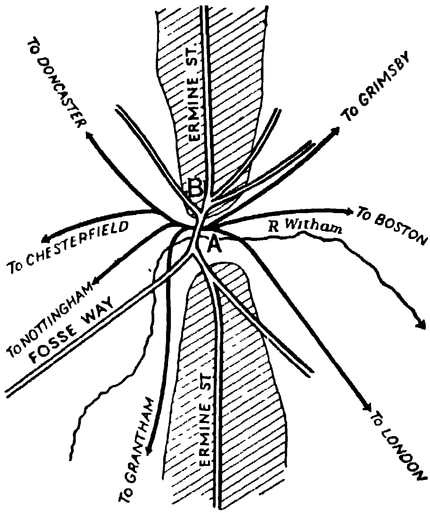

Fig. 169. Lincoln.—Shows the convergence of routes on a gap. The shaded portion is the Lincoln Edge (limestone) through which the River Witham cuts a gap. Double lines are roads and single lines are railways. Note how the old Roman road, Ermine Street, keeps to the unforested hill tops. The old part of Lincoln with its cathedral, markets, etc., is in the high area B. Railway station and factories in lower region A.

(6) Where a river flows through a ridge of hills, *i.e.* a gap. Routes converge on such points just as they do on river bridges, *e.g.* Lincoln (Fig. 169), Guildford, Rheims, Toulouse, Mukden.

(7) Where a river enters or leaves a gorge. A gorge differs from a gap mainly in its length, *e.g.* Ironbridge, where the Severn enters its gorge, and Bridgnorth, where it emerges from the gorge; Bingen and Bonn, on the Rhine; Linz and Vienna, on the Danube; Ichang and Wanshien on the Yangtse-Kiang.

(8) Where a river leaves the narrow valley of the hills for the broad open plains. This is a point at which the hill people and the plains people meet, *e.g.* Leeds, Oswestry, Verona, Dresden.

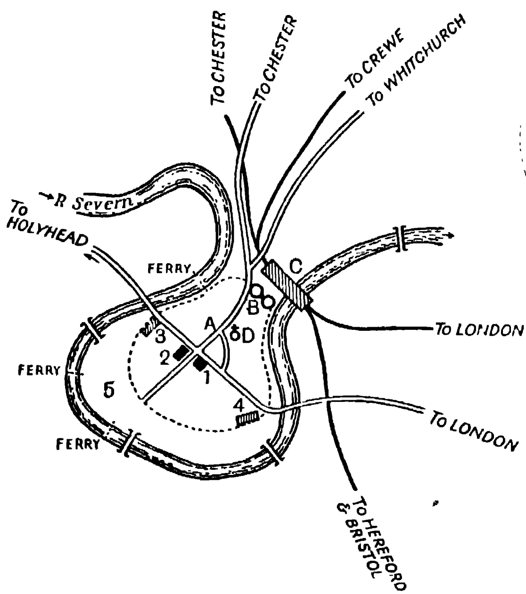

Fig. 170. The Position of Shrewsbury.—The dotted lines represent the position of the old Walls A. The original Market Place near the Church. B. The Castle guarding the "Neck". C. The Railway Station—built over the river because of lack of room. D. The principal church on the highest point of the town. 1. Market Square, second position of market, near main cross-roads. 2. Present Market, third position of market, near main cross-roads. 3. Priory. 4. Friary. 5. Low land—originally marshy—now a park. Note the number of bridges and ferries necessary.

(9) If lakes occur in a river's course they often determine town sites:—

(*a*) Where the river enters the lake, *e.g.* Duluth on Lake Superior and Chicago on Lake Michigan.

(*b*) Where the river leaves the lake, *e.g.* Athlone (on the Shannon), Geneva, and Detroit.

(*c*) Between two lakes, *e.g.* Keswick, between Lakes Derwentwater and Bassenthwaite, and Interlaken, between Lakes Thun and Brienz.

(10) The centre of a fertile plain. The centre of a river's lowland plain is often a great market centre, *e.g.* Glasgow, York, Paris, Harbin.

(11) Where falls occur. Falls impede navigation, but provide power, firstly for water-wheels and later for the development of hydro-electric power, *e.g.* Killaloe (Shannon), Buffalo, Schaffhausen (Rhine), and all the towns of the "fall line" of the Eastern U.S.A.

(12) Within a river loop (Fig. 170). Sometimes a piece of slightly elevated land is almost surrounded by a river loop or "meander". Such a position is primarily important for defence because the river acts as a moat, *e.g.* Shrewsbury, Durham, Paris.

(13) Where the river swings against a steep rock or hill, *e.g.* Nottingham, Budapest.

Other Factors Affecting Town Sites

As already noted, towns may not be situated on large rivers, and may owe their origin to other factors, the chief of which are enumerated below:—

(1) An abundance of mineral wealth usually attracts settlement, *e.g.* Wigan, Kalgoorli, Magnitogorsk (in the Urals).

(2) Coastal towns may owe their importance to (*a*) a good harbour for a small fishing fleet, *e.g.* Whitby; (*b*) a combination of mountain and marine scenery, *e.g.* the seaside resorts of North Wales and Cornwall; (*c*) to a stretch of good sands and bathing facilities, *e.g.* the Lido near Venice, Blankenberghe in Belgium, Blackpool, etc.

(3) In marshy areas such as the Fens, towns grew up where there were firm patches of slightly elevated land, *e.g.* Ely, Wells.

(4) Owing to the increase in the size of ships, many large ports now have an outport nearer the sea, viz. Avonmouth for Bristol, Cuxhaven for Hamburg.

(5) Settlements were often determined by the availability of supplies of fresh water. For this reason there is usually a line of villages along the foot of the chalk or limestone escarpments, where springs occur. Such villages are said to be on the "Spring Line" (see Chapter I, page 31).

The sites of many towns and cities may incorporate a number of natural advantages. For instance, Carlisle is at the

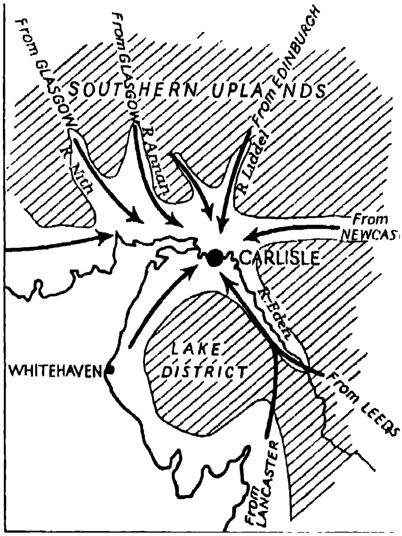

Fig. 171. The Position of Carlisle.—Shows a town located where routes meet.

lowest bridging point of the River Eden; is at a point where firm banks allowed bridge building; is surrounded by streams on three sides, so that the position was suitable for defence; is in the centre of a rich agricultural plain, so that it became a market town; and finally, is at the convergence of a number of natural routes from England and Scotland (Fig. 171). Its function as a route centre has made it, in modern times, a very important railway junction.

CHAPTER XXV

FRONTIERS

The Function of a Frontier

In early days the main idea of a frontier was to keep peoples apart, and its value depended on its efficacy as a "defence". Recent wars have shown that no type of frontier exactly fulfils this condition. Yet frontiers must exist if peoples of different race, nationality, or culture are to be free to choose the form of government best suited to their needs. At the same time frontiers should interfere as little as possible with the free exchange of goods and ideas. Frontiers created after the War of 1914-18 frequently became commercial barriers through the imposition of tariffs and so produced much bitterness. Some *natural* features make good lines or areas of separation, while *artificial* frontiers are rarely satisfactory.

The Sea

The sea is the most perfect of all frontiers, for it not only acts as a defensive moat in time of war, but in peace it is an open highway for the nations of the world. To cross it, unless he goes by modern air transport, man must change his mode of travel. It provides little food and no fresh water, and away from coasts there are no reference points to guide the traveller. Thus, until man had reached a high standard of civilisation and learned to navigate by the sun and stars and the compass, no great width of sea could be crossed. Countries whose frontiers are entirely sea frontiers are indeed well blessed. Because of the double function of the sea as a defence and as an open highway, island peoples possess two diametrically opposed characteristics, the narrow-minded insularity which results from lack of travel abroad, coupled with the broadmindedness of the "Globe-trotting Englishman".

Deserts

Deserts are barriers. They provide neither food nor water except in oases, and the absence of "reference points" in the

monotonous waste makes it difficult for travellers to find their way without the use of a compass. The natural defence provided by the desert protected Egypt in the early days of her history, and so allowed the undisturbed development of an early civilisation. In the same way the desert plateaux of Central Asia have protected China and preserved her isolation and independence, allowing the development of a type of civilisation peculiar to China, uninfluenced until recently by the ideas and ideals of other civilised communities. The Arabian Desert imposed a barrier between Egypt and Babylon, so that trading routes between these two centres had to pass northward through Palestine and Syria to the highways of the "Fertile Crescent". The Sahara Desert is the boundary zone between the black and white races. No great force of men has ever crossed the Sahara, and though there have been experimental endurance tests by various makes of motor cars, the desert still remains a barrier, one to be avoided even in travelling by air, for a forced landing may well prove disastrous.

Mountains

Mountains are barriers because of their ruggedness, their steep slopes, their coldness, their rarefied atmosphere which often causes mountain sickness, their relative infertility and unproductiveness, and because their inhabitants, though few, may, on account of their virility and their intimate knowledge of the details of the relief, offer stout opposition to strangers. Where a mountain range acts as a barrier between two countries, the actual boundary line usually follows the main watershed as in the Western Alps between France and Italy.

The ease with which a mountain range may be crossed depends on the lowness of the passes. The Alps, with numerous passes, are much easier to cross than the "sierra" type of mountain ranges such as the Pyrenees and the Caucasus, although the latter may be of lower average elevation.

Winter snows add to the difficulty of crossing mountainous areas. Even in England the roads of a low plateau like the Pennines may become impassable during the winter. The Pennines, incidentally form a barrier between the fundamentally different districts of Lancashire and Yorkshire, both of which have their characteristic peoples and customs.

Where a mountain range is steeper on one side than the other, the country on the gently sloping side has the advantage. For instance, it is easier for France to invade Italy across the Western Alps than vice versa, a feature which is well illustrated by the fact that the people in the upper valleys of the tributaries of the River Po speak a language closely akin to French. The Andes, between Chile and Argentina, are a good example of a mountain boundary.

Rivers

There is a popular belief that a river is a good natural boundary. This is probably partly due to the prominent part played by the River Danube and the River Rhine in European history. Actually, a river seems to have one main advantage, that of being a line easily discernible, but rivers sometimes change their courses, and resultant problems as to the actual line of the original boundary may arise.

Rivers do not separate peoples of different culture, race, or standard of civilisation. A river attracts settlement, because of the natural routes its valleys afford, its water supply, its fertile alluvial soil, and maybe its forest lands which provide fuel and building material. Thus the people of a river basin are often homogeneous in culture, race, and language, and form a distinct national group. From this it seems that a river basin should be the "heart land" of a country, and not its boundary zone. Egypt grew up around the Nile; Babylon around the Tigris and Euphrates; the Indian civilisation in the Indo-Gangetic plains; and the Chinese civilisation in the Hwang Ho Valley. So Paris, in the centre of the Seine Basin, is the real "heart" of France.

In England rivers are rarely used as county boundaries, except for the Thames, which because of the extensive marshes which used to exist along its banks is a county boundary throughout its length. The River Rio Grande del Norte is the boundary between the U.S.A. and Mexico, but the active frontier is not the river but the desert through which it flows. The River Orange is the boundary between the Cape of Good Hope and South-West Africa, its effectiveness being due to the fact that the river flows through a deep, steep-sided canyon.

The European conception of the Rhine and Danube as international boundaries probably dates back to the time of the Roman Empire. The Romans extended their influence north and east of the Rhine-Danube line, but these rivers acted as a sort of defensive moat against the possible incursions of the semi-civilised tribes to the north and east.

In "new" countries rivers were often chosen as boundaries because of the ease of definition. Thus many of the tributaries of the Mississippi are inter-state boundaries. Other examples are the Uruguay, Parana, and Paraquay in South America; the Vaal, Limpopo, and Zambesi in South Africa; and the Murray in Australia. In the "older" countries of the world rivers are rarely used as frontiers.

Forests

Forests are difficult to penetrate, and were thus avoided by early peoples. The migrations of African natives across the grass-lands, and their avoidance of the forest is clear evidence of the barrier nature of forests to primitive peoples. To-day it is difficult to find examples of forests which act as frontiers, but it could be noted that the eastward extension of the Andean States of South America was probably limited by the Amazon forest lands. In our own country, the northern limits of Sussex were, in part, determined by the forests of the Weald.

Marsh

Marshland is difficult to cross because it provides no foothold, and on it boats cannot sail. During cold winters, however, a marshland loses its effectiveness as a barrier, and when drained its function as such is completely destroyed. Because of the necessity of reclaiming swamps for agriculture few marshland barriers still exist. The best known is the Pripet Marsh or Rokitno Swamp on the boundary of Poland and Russia. The effectiveness of fenland in protecting Athelney and Ely are well known. In 1914 the burgomaster of Nieuport (Belgium) flooded the valley of the Yser between the Belgium coast and Dixmude, thus stopping the German advance to Calais, and in 1940 similar flooding was used to protect allied positions covering the evacuation from Dunkirk.

Artificial Barriers

In olden days walls were built against possible enemies. The Great Wall of China, and Hadrian's Wall in the valley of the River Tyne were constructed as lines of defence. The modern counterpart of the wall is the electrified wire barrier such as was used on the Dutch frontier during the 1914-18 War, and which is still used on the mountain frontiers of Switzerland and Italy. Such modern contrivances are not military defences, but serve as a check on people trying to cross the frontier without permits.

An interesting example of a frontier zone is the uninhabited neutral territory between the Spanish mainland and Gibraltar. While such empty zones are effective in keeping people apart, they involve much waste of valuable land.

A striking feature of the political maps of North America, Australia, and parts of Africa is the number of straight line boundaries. Many of these are lines of latitude and longitude, viz. Latitude 49° N. between Canada and U.S.A.; 141° W. between Canada and Alaska; and 22° N. between Egypt and the Anglo-Egyptian Sudan.

It would seem that such lines have been adopted where settlement has proceeded at a greater rate than the accurate survey of the country. Under such circumstances, governments, unable to delimit natural frontiers, and in haste to fix international or inter-state boundaries, resorted to lines of latitude and longitude as being the quickest and easiest solution of their problems. Such frontiers completely ignore natural features, and, later, may give rise to a crop of knotty problems. This is well seen in South America where, for years, there has been frequent friction between Chile and Peru, and between Paraquay and Bolivia owing to boundary disputes.

The actual survey and the marking of such lines on the ground is very costly, and, in undeveloped areas of little value, is not carried out.

Where, however, valuable products are found, such as the gold of the Yukon-Canada boundary, it becomes imperative that such boundaries should be carefully demarcated.

CHAPTER XXVI

TROPICAL AGRICULTURE

The Difficulties of Tropical Agriculture

Farmers in hot, wet countries have more difficulties to contend with than those of temperate lands. The chief of these difficulties are enumerated below:—

(1) The amazing rate of the growth of vegetation. This is certainly an advantage as far as crops are concerned, but is a great disadvantage in relation to weeds, which grow so rapidly that the farmer has great difficulty in keeping them down under the damp conditions which persist. Native agriculturalists, using primitive ploughs and hoes, are badly equipped to overcome this difficulty.

(2) The number of diseases and insect pests which attack plants is far greater in tropical lands than in temperate lands.

(3) Crops are far more difficult to preserve than in cooler or drier regions, both because they do not keep so well, and because of the actual difficulty of making storehouses proof against the inroads of animals and insects.

(4) Even though climatic conditions favour plant growth, soil conditions are often poor. Much of the soil of tropical areas is a poor reddish soil, known as *laterite*, from which most of the natural plant foods have been dissolved by the heavy rains.

(5) The absence of good roads makes transport and the sale of produce a difficult proposition. There are relatively few roads, and many of these are quagmires of mud and impassable during the rainy season.

(6) Insect pests such as the tsetse fly are fatal to horses and cattle, and exclude the use of these animals from many parts of Africa. In South-East Asia the water buffalo is important because it can withstand the heat and humidity.

(7) The native peoples of tropical areas are with certain exceptions such as the Javanese, of a low level of civilisation. Not only have they little inclination to work because of the enervating conditions, but disease tends to lower their efficiency as well.

Types of Tropical Agriculture

A study of the population map of the world shows that the density of population varies greatly. First of all, there are vast areas which are practically uninhabited. These include desert areas and wide expanses of equatorial forest, scantily inhabited by primitive tribes such as the Amazonian Indians, the Pygmies of Africa, and the backward tribes of the East Indian Islands (excluding Java).

Secondly, there are a few areas with dense population, such as Java.

Thirdly, the remainder consists of vast areas where the population can neither be termed scanty nor dense, but is generally under 100 per square mile.

These three classes of density of population correspond roughly to the various types of tropical agriculture. Where the population is scanty forest tribes mainly hunt for their food, and such agriculture as they practise is of the most primitive type, the planting of a few banana cuttings or a little grain. Between the limits of scanty or dense population as in large sections of Africa, between the Sahara and the Kalahari, and in similar regions of Asia and South America, native peoples practise agriculture of varying degrees of efficiency. Some merely break up the top soil with a hoe, while others use primitive ploughs and raise considerable crops of millet, corn, cotton, etc.

In forest regions natives plant their crops in temporary clearings. After a year or two when the fertility of the soil is exhausted, the plot is abandoned and a new clearing is made. This system of agriculture is known as the Milpa or Fang type of agriculture (see page 244).

The areas of dense population within the tropics are all associated with either rice culture or plantations.

Location of Plantations

Tropical plantations are generally situated on:—

(1) Islands, *e.g.* Java, Jamaica, Hawaii, Mauritius, Cuba, the Philippines, Ceylon, Formosa.

(2) On coastal plains, *e.g.* the coastlands of the Caribbean Sea, Eastern Brazil, East Africa, Eastern Queensland, and Malay.

With few exceptions, plantations are organised by Europeans. It is for this reason that the distribution of plantations is limited, for the problem of transport is not so acute when plantations are near the sea.

Another characteristic of tropical plantations is that many are situated on hill slopes or plateau land, as, for instance, the coffee plantations of Brazil. One of the greatest factors in plantation development is, however, the labour supply. In this respect primitive peoples are of little use. The main reservoir of suitable labour in South-East Asia, which partly accounts for the success of plantation agriculture in the East Indies, in contrast to its absence in Amazonia, remote from supplies of cheap labour.

The Importance of Tropical Products

What tropical products can really be considered important from the point of view of the part they play in world trade? There are certain articles of food such as tea, coffee, cocoa, sugar, and rice, but none of them can compare in bulk or value with the trade in wheat and meat produced in the temperate zone.

Then there are the tropical raw materials, the chief of which is undoubtedly rubber, and there are also various types of hemp. The trade in these raw materials does not approach in value the trade in the wool, flax, and wood pulp of the temperate zone.

In addition to the food and raw materials, fruits, spices, and oil seeds make up most of the balance of the trade from tropical regions.

A study of the list of British imports shows that the meat, wool, wheat, and dairy produce, of the temperate zone are, after petroleum, our leading imports by value. Sugar, tobacco, rubber, and tea, are the leading imports from tropical countries and they rank tenth, eleventh, twelfth, and thirteenth on the list. The value of sugar imported is less than half that of meat, and that of the others is about one quarter. Thus it will be clear that the value of tropical trade is not as great as is popularly imagined. The misconception seems to be due to the fact that, whereas temperate lands supply the necessities of everyday life—the bread and butter, etc.—tropical lands supply those articles which are often the luxuries of life.

QUESTIONS

1. Of the reasons given to prove the earth's shape, which show—
   (*a*) that it has a curved surface?
   (*b*) that it is spherical?

2. The sun is overhead at noon in latitude 10° N. Calculate the height of the midday sun above the horizon at Sydney (N.S.W.), New York, and London.

3. A sailor in the Northern Hemisphere on June 21st observes at midday, looking southwards, that the sun is 5° from the zenith. What is his latitude?

4. Is the midday sun always seen in the south in the Northern Hemisphere? Give reasons.

5. What time will it be in London, Vienna, and Calcutta when it is 10 p.m. Tuesday in New York?

6. Describe the ways in which sedimentary rocks may be formed.

7. Draw a map of England and on it mark and name the chief hill systems of the Jurassic Limestone and Chalk escarpments of England.

8. How may the presence of (*a*) chalk, (*b*) limestone in an area be recognised by studying an O.S. map?

9. What do you understand by the terms—horst, mesa, gneiss, residual mountain, peneplain?

10. Give examples of the various ways in which plains have been formed.

11. Of what economic value to man are the great mountain systems of the world?

12. "Winds are the chief cause of ocean currents." Discuss this by reference to the principal currents of the Indian Ocean.

13. Show how the climates of the coastlands may be affected by ocean currents from a consideration of the coasts and islands of the North Atlantic.

14. Distinguish between Spring and Neap Tides.

15. Explain why most places on the coasts of the British Isles have two tides each day. Account for any exceptions.

16. Why does the height of the tide vary (*a*) in different seas; (*b*) at the same place; (*c*) on different days? Give examples.

17 How do the tides affect the ports of the British Isles?

18. Draw a profile of a river in the British Isles selected from your atlas map to illustrate the variations in gradient from source to mouth. Name each section.

19. Describe briefly the effects of ice-sheets passing over a region. How may these glacial effects prove helpful to man?

20. Make a list of the chief lakes of each continent and classify them according to their formation.

21. Examine the coastline of any available Ordnance Survey map and describe its chief features.

22. Obtain pictures of fiord scenery and describe the characteristics of this type of coastline.

23. How are the (*a*) food; (*b*) shelter; and (*c*) clothing of Eskimos, Pygmies, and Kirghiz affected by the environment in which they live respectively?

24. How is it that the Lower Ganges Valley is densely peopled and the Lower Indus Valley is scantily populated?

25. By making allowance for altitude, and finding the hottest month, annual range of temperature, mean annual temperature, the total rainfall and its seasonal distribution, try to decide in what natural region each of the following places A to M are situated:—

CLIMATE STATISTICS

The first row of figures gives temperature in F.°, and second row infall in inches.

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
A	71	74	83	92	95	94	89	86	89	88	80	71
520′	0	0	0·1	0	0·3	0·9	3·5	2·8	1·1	0·4	0	0
B	23	24	24	28	33	40	42	41	38	31	29	25
4400′	19	15	17	10	8	8	11	14	17	15	19	21
C	20	23	36	50	62	71	76	74	65	54	37	27
100′	0·6	0·8	1·4	3·0	4·4	5·2	4·4	3·4	3·0	2·5	1·0	0·9
D	62	63	59	55	50	47	46	48	51	54	57	60
160′	1·8	1·5	1·6	1·8	1·9	2·2	2·1	1·8	2·2	2·2	2·5	1·9
E	65	68	72	74	79	81	82	83	81	77	73	69
5′	3·3	2·5	2·8	3·2	5·9	7·9	7·2	7·3	9·9	9·2	2·2	2·2
F	62	62	61	57	53	49	47	48	51	54	57	60
143′	3·6	3·2	3·1	4·1	4·6	5·0	5·9	5·0	4·2	3·9	3·6	3·3
G	75	75	78	82	85	82	80	79	79	81	79	76
37′	0	0	0	0·1	0·5	21	25	15	11	2	0·5	0·1
H	78	79	80	81	82	81	81	81	80	80	79	79
104′	8·5	6·1	6·5	6·9	7·2	6·7	6·8	8·5	7·1	9·2	10	10
I	51	52	55	59	64	71	76	77	73	67	59	53
60′	4·1	3·1	3·2	2·6	1·3	0·6	0·3	0·6	1·5	4·0	4·0	4·5
J	55	59	65	70	77	85	91	90	84	72	61	56
141′	0·4	0·5	0·1	0	0	0·1	0·5	0·2	0·2	0·2	0·2	0·3
K	−1	5	15	33	48	60	66	60	48	33	14	1
340′	0·7	0·6	0·7	0·8	1·3	2·7	3·5	3·2	1·5	1·4	1·3	0·9
L	39	39	40	45	50	55	57	56	53	47	44	40
171′	8·7	6·9	7·0	4·0	3·5	3·5	4·6	6·9	8·2	7·9	7·5	11·3
M	74	74	71	67	60	56	55	56	58	61	65	71
197′	0·3	0·3	0·7	1·7	4·9	6·6	6·4	5·6	3·3	2·1	0·8	0·6

26. Why does North Australia have rainfall chiefly in summer, and Southern Australia have rainfall chiefly in winter?

27. How would the size of farms and cultivated products differ in the following regions: (*a*) Manitoba; (*b*) Alberta; (*c*) Japan?
Why do these differences occur?

28. Rainfall decreases from latitude 60° N. to the tropic on the west of a continent and increases from latitude 60° N. to the tropic on the east coast of a continent. Why is this?

29. Where and what are the Llanos, Selvas, Campos, Barren Lands, Pampas, and Steppe?

30. Compare the climates of Eastern Siberia and the St Lawrence Valley and account for differences.

31. Give two examples of natural regions in which the corresponding areas on opposite sides of the equator differ climatically. Give details of these differences and add explanatory notes.

32. Consider carefully the geographical position of Russia and suggest reasons for her efforts to develop the Arctic coast-line.

33. Explain (*a*) why all forested areas in temperate latitudes are not important lumbering areas; (*b*) why lumbering is less important in equatorial regions than in temperate areas

34. Compare the Savana Lands of Africa, north and south of the equator.

35. Give examples of important commodities which (*a*) Great Britain, (*b*) U.S.A , cannot obtain in sufficient quantities from their own possessions.
What are the sources of supply and to what extent might these countries become self-supporting in the future?

36. (*a*) What commodities does Great Britain import mainly from the Asiatic monsoon lands?
(*b*) What alternative sources of supply exist for the commodities selected?

37. Give examples of air routes which have considerably shortened distances between important ports now that Polar routes have become practicable.

38. Essay Subjects.
1. White Australia.
2. Transcontinental Railways.
3. Intercontinental Air Routes.
4. Mandated Territories.
5. The Lancashire Cotton Industry
6. The Development of the Beet-Sugar Industry.
7. The Value of Tropical Colonies to European Powers
8. Rayon and Nylon.
9. Natural and Synthetic Rubber.
10. The Economic Strength of the U.S.S.R.
11. The Growth of Self-Government in Asia.
12. New Industries.

EXAMINATION QUESTIONS

The following questions have been reproduced by permission of the various Examining Bodies concerned from examination papers at the Ordinary Level of the General Certificate of Education. Questions marked with an asterisk are from *Alternative* papers.

(*C.*) Cambridge, (*L.*) London, (*N.*) Northern Universities, (*O.*) Oxford, (*O. & C.*) Oxford and Cambridge Joint Board.

1. Describe with the aid of diagrams *three* important land forms which may result from faulting, giving examples where possible. (*O. & C.*)

2.* By reference to some specific regions, compare the effects of ice action on mountain areas with those on lowland areas. (*O. & C.*)

3.* Describe the nature and origin of *three* of the following: raised beaches, sand spits, rias, coral reefs. (*O. & C.*)

4 Three different types of scenery are represented by the following three pairs of physical features:—

hanging valley	swallow-hole	ox-bow lake
terminal moraine	underground cavern	levée

Choose *one* feature from each group and (*a*) with the aid of diagrams, briefly describe the feature and the way it was formed; (*b*) locate an area in which an example occurs. (*C.*)

5. For *each* of the following, a young folded mountain region, a plateau, a scarpland: (*a*) attempt a sketch section to show the type of relief, indicating the approximate vertical and horizontal scale employed; (*b*) name and locate a region in which such relief may be found. (*C.*)

6. Choose *three* of the following physical features. sand dune, fiord, ox-bow lake, sea cliff. For *each* chosen feature describe the appearance and mode of formation, and name and locate an area where an example may be seen. (*C.*)

7. What are the characteristic physical features you would expect to find in (*a*) a young river valley; (*b*) a maturer river valley; (*c*) a delta? Illustrate your answers with diagrams and examples. (*L.*)

8. Choose two of the following land forms: a glaciated mountain valley, an atoll, a rift valley, an alluvial plain. For each of the two chosen:—

(*a*) Name an example or a region where an example is to be found.

(*b*) Describe its characteristic features.

(*c*) State *one* way in which it influences the life of people associated with it. (*L.*)

9. Describe and explain (*a*) the special characteristics which are generally to be observed in a "young" river valley, and (*b*) the work done by wind in modelling the earth's surface. (*L.*)

10. Explain, with the aid of sketch maps, or diagrams, any *three* of the following terms: alluvial plain, continental shelf, delta, hanging valley, terminal moraine. (*L.*)

11.* Illustrating your answer with diagrams, describe the development of a river system in an area tilted towards the sea and consisting of alternate beds of hard and soft rock outcropping parallel to the coast. (*O. & C.*)

12.* By reference to specific examples describe the chief constructive and destructive processes at work along coasts and some of the resulting land forms. (*O. & C.*)

13.* Make a classification of mountains based on their modes of origin, giving examples of each type. (*O. & C.*)

14.* Mention *one* area in each of *three* different continents which has been affected by soil erosion. Explain how man has assisted the erosion of the soil, note its effects on agriculture, and describe changes in farming practice designed to reduce such erosion. (*O. & C.*)

15. Describe, with the aid of diagrams, and explain the formation of *three* of the following: arête, hanging valley, fiord, esker, boulder clay (*O. & C.*)

16.* Give an account of (*a*) the destructive, and (*b*) the constructive work of rivers in the evolution of landscape in temperate humid regions. (*O. & C.*)

17.* Write a short essay on marine erosion and deposition. (*O. & C.*)

18.* Where and why does soil erosion occur on a large scale? Describe some methods used to combat the problem. (*O. & C.*)

19. With the aid of diagrams explain the formation of fold mountains, rift valleys, and flood plains. (*O. & C.*)

20. Choose *three* of the following terms: flood plain, pastoral nomadism, dissected plateau, fiord coast, scrub vegetation, insular climate. State the meaning of each term chosen, give *one* area where the feature is well developed and show how it affects the life of the people in the area. (*N.*)

21. Choose two of the following pairs: (*a*) equatorial and coniferous forests; (*b*) estuarine coasts and fiord coasts; (*c*) coastal uplands and interior uplands; (*d*) winter rainfall and summer rainfall areas. Name *one* area illustrating each of the four types selected. For each pair of areas you have named show how the differences in natural conditions have helped to bring about differences in the way of life of the inhabitants. (*N.*)

22. The following difficulties are encountered by farmers in various parts of the world: (*a*) soil erosion; (*b*) lack of rainfall; (*c*) insect pests; (*d*) river flooding. Choose *two* of these difficulties and for each (i) name *one* area where it occurs; (ii) describe the nature of the problem; (iii) describe the steps which are taken to overcome it. (*N.*)

23.* Describe the atmospheric conditions giving rise to each of the following forms of precipitation: rain, fog, snow, hail. (*O. & C.*)

24.* By reference to specific examples, discuss the factors responsible for variations in the salinity of the waters of oceans and seas. (*O. & C.*)

25.* Describe and account for *three* different types of climate experienced between latitudes 40° N. and 60° N. and locate *one* area experiencing each type. (*O. & C.*)

26.* Describe the world distribution of hot deserts, and discuss the action of wind in the development of land forms in these regions. (*O. & C.*)

27. Describe and account for the variations in salinity of the oceans and seas of the Northern Hemisphere. (*O.* & *C.*)

28. Describe and account for the natural vegetation which is characteristic of (*a*) steppe grass-land areas, (*b*) savana areas. (*O.* & *C.*)

29. Describe and account for the movement of the surface water of *either* the North Atlantic Ocean *or* the South Atlantic Ocean. (*O.* & *C.*)

30. State and explain the chief differences between the natural vegetation of temperate deciduous and tropical monsoon forest areas. (*O.* & *C.*)

31.* Explain why the water which lies just off the coast of North-West Europe is the warmest for its latitude of any ocean water in the world. (*O.* & *C.*)

32. (*a*) Locate *four* areas outside Europe which have rain in winter only. (*b*) What are the other climatic features of these regions? (*c*) Explain carefully how the plant life is adapted to this type of climate. (*d*) State, with a reason, one type of farming favoured by this type of climate. (*O.*)

33. For each of *two* of the following types of natural vegetation—coniferous forest, temperate grass-land, tundra, savana: (*a*) name and locate an area where it grows; (*b*) explain how its characteristic features are influenced by the climate of the area; (*c*) name an animal particularly associated with that type of vegetation, giving *one* reason why it thrives in the area. (*C.*)

34. Explain *three* of the following statements giving, where possible, examples to illustrate your answer:—

(*a*) Natural vegetation characteristics are strongly influenced by climate.

(*b*) In some countries there are twice as many hours of daylight in June as there are in December.

(*c*) Soil erosion often results from misuse of the land.

(*d*) Ocean currents may influence the climate of adjacent coast-lines. (*C.*)

35. Some groups of people have no permanent habitation; they move to another locality after a period of time. Give *two* examples of such groups in different vegetation regions, and in each case show how the periodic movement is forced on the people (*O.*)

36. Wheat, butter, tea, and sugar are four foods produced within the British Commonwealth and Empire and exported to Great Britain. Select *three* of these and, for *each one*, (*a*) name an area within the Commonwealth and Empire which produces it for export; (*b*) describe the conditions under which it is produced in the named area. (*O.*)

37.* Compare the geographical conditions favouring the production of wheat and maize, and examine the world trade in these two commodities. (*O.* & *C.*)

38. Describe the geographical conditions which favour the production of (*a*) rubber, (*b*) jute. In each case, name *one* important producing area, and discuss the uses of the commodity to man. (*O.* & *C.*)

39. Describe the physical and economic conditions which favour the production of (*a*) coffee, (*b*) cocoa. In each case draw a sketch map to show an important producing area and its chief ports. (*O. & C.*)

40. Write a geographical account of any *two* of the following: wheat farming in Australia; cotton growing in the U.S.A.; sugar production in the West Indies; fruit growing in the Union of South Africa; dairying in New Zealand. (*L.*)

41. Locate the world's chief sources of any *two* of the following: tea, plantation rubber, coffee, ground-nuts. Describe the geographical conditions of production of the two commodities you select. (*L.*)

42. Write a short geographical account of any *two* of the following:—

(*a*) The utilisation of the tropical area of Australia.

(*b*) The mineral resources of the Union of South Africa.

(*c*) Terrace cultivation in Asia. (*L.*)

43.* Discuss the advantages and disadvantages of rivers as boundaries between states, illustrating your answer by reference to *one* European example. (*O. & C.*)

44.* Give *two* examples in Europe where mountains form a frontier dividing two nations, and *two* where mountains have acted as a means of uniting a nation. Explain why the mountains in each case act *either* as a means of dividing nations *or* as a means of uniting a nation. (*O. & C.*)

45. What are the relative advantages and disadvantages of transporting goods by road, rail, and canal? Give examples to illustrate your answer. (*O. & C.*)

46. Name two areas of the world where railway transport is little developed and give reasons for this lack of development. Describe other methods of transport used in these areas and explain how they are suited to the geographical conditions of the area. (*L.*)

47. Describe the importance as a means of communication of *three* of the following: the Trans-Siberian Railway; the River Congo; the Straits of Malacca; the Panama Canal. (*L.*)

48. Choose *three* of the following towns and show how the importance of each has been influenced by its position: Aberdeen, Carlisle, Edinburgh, Inverness, Perth, Stirling. (*L.*)

49. Show, with the help of sketch maps, how geographical factors have influenced the development of *three* of the following: Antwerp, Barcelona, Bordeaux, Duisberg, Genoa, Marseilles, Rome. (*L.*)

50. Select three major seaports of Europe, situated, *one* in the Atlantic, *one* in the Baltic, and *one* in the Mediterranean. Describe the position and character of the trade of each. Sketch maps are required. (*L.*)

51. State the main geographical conditions which can contribute to the development of important seaports. Select *one* port in Africa, and *one* in South America and explain, with the aid of sketch maps, how the development of each of these two ports has been influenced by the conditions you have stated. (*L.*)

52. Describe with the aid of sketch maps the position and importance of *three* of the following towns: Boston, Los Angeles, Montreal, New York, Vancouver. (*L.*)

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